Expected trends and surprises in the Lateglacial and Holocene vegetation history of the Iberian Peninsula and Balearic Islands

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Abstract

Recent, high-resolution palaeoecological records are changing the traditional picture of post-glacial vegetation succession in the Iberian Peninsula. In addition to the influence of Lateglacial and early Holocene climatic changes, other factors are critical in the course of vegetation development and we observe strong regional differences. The floristic composition, location and structure of glacial tree populations and communities may have been primary causes of vegetation development. Refugial populations in the Baetic cordilleras would have been a source, but not the only one, for the early Lateglacial oak expansions. From Mid to Late Holocene, inertial, resilient, and rapid responses of vegetation to climatic change are described, and regional differences in the response are stressed. The role of fire, pastoralism, agriculture, and other anthropogenic disturbances (such as mining), during the Copper, Bronze, Iberian, and Roman times, is analysed. The implications of ecological transitions in cultural changes, especially when they occur as societal collapses, are discussed.

Key words: palaeoecology, palaeogeography, palaeobotany, Iberia, Quaternary, Holocene

INTRODUCTION

Over the last few years, the number of Lateglacial and Holocene records in the Iberian Peninsula has increased considerably. This is particularly true in the case of pollen sequences (Carrión et al. 2007, Fletcher et al. 2007, Muñoz-Sobrino et al. 2007, González-Sampériz et al. 2008) and to a lesser extent in the case of anthracological (Badal et al. 2008) and other macrobotanical records (García-Amorena et al. 2007, Postigo et al. 2008). It was only some decades ago that the publication of palaeoecological sequences without absolute dating was relatively frequent (Dupré 1988, Carrión 1992, Martínez-Atienza 1999). However the chronological control of palaeo-records

50 has improved considerably, probably due to the consolidation of research groups and a better
51 access to research funding programmes.
52 In this context, the present work aims to understand the vegetation change patterns, and
53 their causes, during the Late Quaternary in the Iberian Peninsula and the Balearic Islands. We
54 examine two different time periods: first, the Lateglacial (14,700-11,500 cal. yr BP) and early
55 Holocene (after 11,500 cal. yr BP), when the deglaciation process was concurrent with global
56 warming (Bradley 2008). In this regard we assess to what extent this multimillennial event was
57 the main controlling factor in the vegetation response, or if instead autoecological processes and
58 high regional topographical variability were more important in regulating the vegetation changes
59 produced (Bennett and Willis 1995). Our second scenario is defined by the appearance of human
60 activity indicators in the palaeoecological record. The emergence of anthropogenic events is
61 detected in some sequences from the Mid-Holocene while it is delayed in others (Carrión et al.
62 2009).
63 This paper is the first attempt to review the topic for the whole of the Iberian Peninsula.
64 This is not an easy task, given the physiographical complexity of this area and the information
65 gaps both in time periods and provinces,. We are conscious that the adopted duality (expected
66 *versus* unexpected) may be considered artificial: making a visual inspection of the palaeo-records
67 reveals that there is a continuum in vegetation histories. However, dichotomizing serves a
68 purpose: separating the histories of directional change through time from those that exhibit
69 apparently accidental trajectories, including those that lack significant change. This approach is a
70 test of how to conceptualize the apparently chaotic picture of vegetational developments (Carrión
71 et al. 2000). Often being too busy with the analytical work, we have concentrated on the gaining
72 of new records over the production of theories. But it is our view that observations and theory
73 should be merged and should interact continuously.
74

METHODOLOGICAL CONSIDERATIONS

We select palaeoecological sequences that exhibit appropriate chronological control of the main vegetation changes at the resolution needed for this paper´s goal. These are only a small fraction of those available, because a number of palaeobotanical records were never dated or are based on fragmentary information. In this regard, a good part of the pollen-analytical effort has been in vain. Carrión et al. (2009) have reported failures with Quaternary pollen analyses in the Iberian Peninsula, that is, case studies where it was not possible to extract palynomorphs for pollen counting. Compiled failures included 204 sites, from which 48.8% were Holocene, and 31.4% Upper Pleistocene. It is therefore worth pondering what the prevailing paradigm of Late Quaternary vegetation of Iberia would have been had these analyses had been successful. As for the study of past fire activity, the lack of continuous, long charcoal sequences prevents any attempt to assess fire regimes and environmental changes at high time resolution. The reconstruction of fire activity is therefore particularly difficult as a consequence of stratigraphical hiatuses in the archaeological sites and the absence of regional information available from charcoal records, in assemblages that are in any case often biased by human selection during harvesting.

An additional problem precluding palaeoenvironmental correlation as well as an adequate regional picture is the absence of open access national databases and repositories as the EPD (European Pollen Database: http://www.europeanpollendatabase.net/) initiative. Some recent proposals such as PALEODIVERSITAS (http://www.paleodiversitas.org/) and LA FLORA EN EL MUNDO IBERICO (http://www.uv.es/floraiberica) intend to cover this lack of information, although these are still in very preliminary phases. As a consequence of all these aspects, quantitative approaches to regional reconstructions are not available yet.

PALAEOECOLOGICAL INDICATORS

In order to elucidate the influences and controls on vegetation change, we have largely followed the interpretation given by authors in their publications, especially for detecting the timing of the first anthropogenically-influenced changes. When possible, we have considered palaeoecological bio-indicators from the same sedimentary record studied by pollen and/or macroremains. In the palaeobotanical literature for the Late Quaternary in the Iberian Peninsula, these mainly include:

- Aridity crises: pollen of xerophytes and halophytes (*Artemisia, Ephedra*, Chenopodiaceae, *Lygeum, Lycium, Periploca, Ziziphus, Withania, Sideritis, Tamarix,* Aizoaceae), and *Pseudoschizaea* cysts (Pantaleón-Cano et al. 1996, Burjachs et al. 1997, Carrión and Navarro 2002, Dorado-Valiño et al. 2002, Carrión et al. 2003, González-Sampériz et al. 2005, 2008, Gil-García et al. 2007, Fletcher et al. 2007, Valero-Garcés et al. 2000a, 2000b, 2004).
- Increased rainfall / reduced summer drought: *Botryococcus, Pediastrum*, mesophyte pollen, aquatic angiosperm pollen (e.g. *Myriophyllum, Potamogeton, Hydrocotyle, Typha, Alisma, Nuphar, Callitriche*, *Hydrocharis*, *Lemna, Sparganium*), aquatic lycophyte (*Isoetes*) and fern (e.g. *Botrychium, Ophioglossum*) spores (López-Sáez et al. 1998, Carrión and van Geel 1999, Carrión et al. 2001a, 2001b, Carrión 2002, González-Sampériz et al. 2008, 2009, Valero-Garcés et al. 2008, Moreno et al. 2009, in press).
- Soil erosion: Glomaceae chlamydospores, *Pseudoschizaea* (Pantaleón et al. 1996, López-Sáez et al. 2000).
- Trophic conditions: Zygnematales, Desmidiales, *Chara* gyrogonites, Cyperaceae and *Juncus* seeds, Protozoa, cyanobacteria (e.g. *Gloeotrichia, Rivularia*), (Mateus 1989, López-Sáez et al. 1998, 2000), and several of the non-pollen palynomorphs described by van Geel et al. (1981, 1986, 1989) and Carrión and van Geel (1999) such as Types 119, 121, and several other types.

- Agriculture / arboriculture: Cerealia*, Polygonum aviculare, Plantago lanceolata-coronopus, Plantago major-media* types, *Rumex, Cannabis, Vitis, Puccinia* teleutospores and *Thecaphora* basidiospores, occasionally *Juglans, Castanea, Fraxinus* and *Olea* (Stevenson 1985, Stevenson and Moore 1988, Tornqvist et al. 1989, Janssen 1994, van der Knaap and van Leeuwen 1995, Franco-Múgica et al. 1997, Conedera et al. 2004, López-García et al. 1997, Carrión et al. 2001b, 2007, Valero-Garcés et al. 2000a, 2000b, 2004, López-Sáez et al. 2003, González-Sampériz 2004, López-Sáez and López-Merino 2005, Moreno et al. 2008.
- Grazing pressure: Sordariaceae (e.g. *Chaetomium, Sordaria, Podospora, Sporormiella*) ascospores, *Riccia* spores, *Trichuris* eggs*,* Genisteae, *Plantago, Berberis, Urtica dioica* (Montserrat 1992, Carrión 2001b, Carrión and Navarro 2002, López-Sáez and López-Merino 2007).
- Fire events/ increased burning: macro/microcharcoal particles, Cistaceae, *Erica, Ulex* type, *Asphodelus albus, Anagallis arvensis* type*, Pteridium* spores, *Chaetomium* and other carbonicolous fungal spores (Carrión and van Geel 1999, Carrión 2002, Carrión et al. 2003, 2007, López-Sáez et al. 1998, 2000, Stevenson 2000).

IBERIAN VEGETATION COPING WITH THE LATEGLACIAL-EARLY HOLOCENE CLIMATIC CHANGE

The Iberian Peninsula constitutes a territory where climatic, geological, biogeographical and historical conditions converge to produce environmental heterogeneity, large biological diversity, and a remarkable species and ecosystem richness (Rey Benayas and Schneider 2002). The flora of the Iberian Peninsula and Balearic Islands is located in two biogeographical/climatic regions: Eurosiberian and Mediterranean. The first includes the territories located to the north and the northwest of the Peninsula, with wet, cool climate and without marked summer drought, whereas

150 the rest of the peninsular territory, including the Balearic Islands, enters within the domain of the
151 Mediterranean region, with warm, dry summers and relatively cool, wet winters (Peinado and
152 Rivas-Martínez 1987).

153 A monographic description of the variability of sequences in the whole Peninsula is
154 beyond the scope of this paper. Rather, given the high diversity of the ecosystems, our synthesis
155 deploys a classification of fast-responding records to increasing temperatures giving place to
156 expected vegetation dynamics (*Expected Sequences*) *versus* those cases less sensitive to
157 climate change (*Unexpected Sequences*). We will also include within "unexpected" those
158 situations which, despite existent vegetation reactivity, the dynamics observed do not correspond
159 with the most frequent cases. Changes in rainfall patterns during the Lateglacial and Early
160 Holocene periods were produced at different spatial scales and there is no agreement about their
161 potential synchronicity in the peninsula (e.g. Valero-Garcés et al. 2004).

162

163 *EXPECTED SEQUENCES: climate-sensitive vegetation changes*

164 It is expected that during the Lateglacial and Early Holocene, a counterpart of the high-latitude
165 European protocratic and mesocractic phases (Birks 1986) is found in the Iberian Peninsula. On
166 a global scale, during the Last Glacial Maximum (LGM), temperature and precipitation reached
167 minimum values, and north European landscapes were dominated by treeless tundra and prairie-
168 steppe. Refugia for forest vegetation occurred in southern Europe (Finlayson and Carrión 2007,
169 Leroy and Arpe 2007, Médail and Diadema 2009) and particular regions of central Europe (Willis
170 and van Andel 2004), perhaps with cryptic refugia (areas of sheltered topography that provided
171 suitable stable microclimates) in northern latitudes (Bhagwat and Willis 2008, Provan and Bennett
172 2008, Stewart and Dalén 2008). But by the Lateglacial period, *Pinus, Juniperus,* and *Betula*, and
173 then *Quercus* spread northward from southern European localities. The Younger Dryas cold
174 period interrupted this trend for several centuries between ca. 12,650 and 11,500 cal. yr BP. The

175 onset of the Holocene witnessed range expansions of angiosperm trees (*Corylus, Alnus,*
176 *Fraxinus, Ulmus, Acer, Abies, Fagus,* and *Quercus*). Approximately 6000 years ago northern
177 hemisphere ice pulled back to near modern limits, and most European forests reached their
178 maximum extent. According to this picture, as discussed by Carrión (2001a), pollen diagrams
179 from the southern European peninsulas show most of the following characteristics: (i) increases
180 of *Quercus* pollen since lateglacial period, with the earliest occurrences in southernmost and
181 coastal regions and the thermomediterranean belt, (ii) evidence for the Younger Dryas cold
182 period in the form of expansion of xerophytes, and (iii) mesic tree forest maxima during the first
183 Holocene millennia. Vegetation sequences near the current mountain treeline were characterized
184 by open *Pinus* and *Juniperus* woodlands (Peñalba 1994). Divergences from this basic pattern
185 have been often considered as result of site constraints or regional climate heterogeneity (e.g.
186 Ramil-Rego et al., 1998, Muñoz-Sobrino et al. 2001).
187 Abundant examples exist of sequences corresponding to this dynamic model, especially
188 in the Eurosiberian Region and areas under the Atlantic influence; Galicia, Portugal and south-
189 western Spain (Figs. 1 and 2). These include the pollen records of Lago Enol in the north (López-
190 Merino 2009), Tramacastilla and El Portalet in the Pyrenees (Montserrat 1992, González-
191 Sampériz et al. 2006), Banyoles in the northeast (Pérez-Obiol and Julià 1994) (Fig. 2), Pozo do
192 Carballal (Muñoz-Sobrino et al. 1997) and Sanabria (Allen et al. 1996) in the northwest (Figs. 2-
193 3), Lagoa Marinho in Sierra de Geres of northern Portugal (Ramil-Rego et al. 1993a), Lagoa
194 Comprida (van den Brink and Janssen 1985) and Charco da Candieira in Serra da Estrela,
195 central Portugal (van der Kaap and van Leeuwen 1995) (Fig. 4), and Padul in the southeast,
196 northwest of the Sierra Nevada (Pons and Reille 1988) (Fig. 2). The situation in the island of
197 Ibiza, with the pollen sequences of Prat de Vila and Prats de ses Monges (Yll et al. 2009), fits into
198 this expected pattern. Among the charcoal records, the most complete are probably Mougás in
199 the Eurosiberian region (Carrión-Marco 2003), and Buraca Grande, Cabeço do Porto Marinho,

200 Cova de les Cendres and Tossal de la Roca in the Mediterranean Region (Fig. 5). Other
201 macroremains (leaves, twigs, trunks, etc) provide information on the species involved. Thus, the
202 Eurosiberian region is noted for the abundance of *Quercus robur, Q. petraea, Q. ilex, Salix*
203 *atrocinerea, Corylus avellana, Fagus sylvatica, Abies alba, Pinus sylvestris, P. nigra, Acer*
204 *pseudoplatanus, Arbutus unedo,* and *Alnus glutinosa*, among others (García-Antón et al. 2006,
205 García-Amorena et al. 2007, 2008). For the Mediterranean region, there are macroremains of
206 *Quercus ilex-rotundifolia, Q. pyrenaica, Q. faginea, Pinus halepensis, P. pinaster, P. nigra, P.*
207 *pinea, Olea europaea,* and *Populus nigra*, among others (García-Amorena et al. 2008). Finally,
208 marine sediment pollen records such as MD99-2331 (Naughton et al. 2007), MD03-2697
209 (Naughton et al. 2007), SU-8118 (Parra 1994), MD95-2042 (Sánchez-Goñi et al. 2002), SU-8113
210 (Parra 1994), MD95-2043 (Sánchez-Goñi et al. 2002), and SU8103 (Parra 1994) confirm that
211 these overall trends.
212 Variations within the "expected" can be explained by the topographical context of the
213 different sites. For instance, continentality, altitude and aridity may have circumstancially favoured
214 *Pinus* in opposition to *Quercus*. Thus, the existence of *Pinus* woodlands during the Lateglacial
215 and Early Holocene as a consequence of the orographic influence is a widespread feature in
216 several of the Iberian mountain pollen records, such as Lago Enol (López-Merino 2009), Comeya
217 (Ruíz-Zapata et al. 2001), Polvoredo (García-Rovés 2007), San Isidro (Fombella Blanco et al.
218 2003) and Lago Mayor del Valle (Allen et al. 1996) in the Cantabrian range; Lagoa Lucenza
219 (Muñoz-Sobrino et al. 2001) in Galicia, El Portalet (González-Sampériz et al. 2006) in the
220 Pyrenees, and Llauset (Montserrat and Vilaplana 1987), Quintanar de la Sierra (Peñalba et al.
221 1997, Ruíz-Zapata et al. 2002), Hoyos de Iregua (Gil-García et al. 2002, Gil-García and Ruíz-
222 Zapata 2004) and Las Pardillas (Sánchez-Goñi and Hannon 1999) in the Iberian range (Fig. 1).
223 Similarly, typical summer drought conditions like in the Central Ebro depression at sites like Hoya
224 del Castillo and Laguna Guállar (Zaragoza) may have contributed to the occurrence of *Pinus*

225 woodlands during the Lateglacial (Davis and Stevenson 2007). In southern Iberia, *Pinus* prevailed
226 during the Early Holocene in the high-elevation Sierra de Baza (Carrión et al. 2007), the dry
227 lowlands of Elx (Burjachs and Riera 1995) and the Guadiana Estuary in the southwest (Fletcher
228 et al. 2007) (Fig. 2). The Atlantic coast pollen record 8057B confirms this pattern (Hooghiemstra
229 et al. 1992).

230 As for the pine distribution in these records, *Pinus nigra* and *Pinus sylvestris* would have
231 been widespread at high altitudes (Rubiales et al. 2007, García-Amorena et al. 2007, 2008), while
232 *Pinus pinea* appeared in the south and thermomediterranean southwest, both in the Pleistocene
233 and Holocene (Badal 1998, 2006, Carrión et al. 2008), and *Pinus halepensis* abounded in the
234 east and Ebro Valley (Badal 2004, Badal et al. 1994, 2008, Allué 2002, Carrión-Marco 2005).
235 *Pinus uncinata* and *Pinus sylvestris* would have formed the timberline in the Eurosiberian region
236 (Heinz 1991, Uzquiano 1992a,1992b, Carrión-Marco 2005) (Fig. 5). The cluster pine (*Pinus*
237 *pinaster*) would have been sporadically dominant in several Iberian mountains (Figueiral 1995,
238 Figueiral and Terral 2002, Rubiales et al. 2009), and sometimes forming part of mesophytic
239 forests with deciduous *Quercus* (Carrión et al. 2000, 2004, 2007, Rubiales et al. 2009). Charcoal
240 analyses suggest that during the Lateglacial, alpine, subalpine, and oromediterranean pine
241 species descended to the thermo and mesomediterranean belts, disappearing progressively
242 throughout the Holocene (Badal et al. 2008) (Fig. 5), although exhibiting an extraordinarily long
243 residence in some areas (Rubiales et al. 2007).

244 *Juniperus* sometimes accompanied *Pinus* and *Quercus* in the lateglacial and early
245 Holocene woodlands of the continental Mediterranean areas. The pollen records of Salines (Giralt
246 et al. 1999) and Salada Mediana (Valero-Garcés et al. 2000a, 2000b) and the charcoal records of
247 Santa Maria (Carrión-Marco 2005, Aura et al. 2006), and La Falguera (Carrión-Marco 2005)
248 illustrate this case. Other variants of the expected trend include abundance of *Betula* in humid
249 sites of higher altitudes (Muñoz-Sobrino et al. 2004, López-Merino 2009); abundance of *Corylus*

250 in mesothermic Eurosiberian regions such as the Cantabrian coast (Burjachs and Renault-
251 Miskovsky 1992, Peñalba 1994, López-Merino 2009) (Fig. 3) and Mediterranean riparian areas
252 such as Salada Mediana (Valero-Garcés et al. 2000a, 2000b); and abundance of *Olea* in the
253 thermomediterranean belt like in Laguna de Medina (Reed et al. 2001). The colonisation by
254 *Fagus* is generally time-transgressive, starting during the Lateglacial in Sierra de Neila, but
255 delaying its arrival to c. 5700 cal. yr BP or even later in most of northern Spain (Ramil-Rego et al.
256 2000, López-Merino et al. 2008, Muñoz-Sobrino et al. 2009).

257 The Younger Dryas (12,650-11,500 cal. yr BP) of Iberia, as with other regions of the
258 northern hemisphere, does not always have a clear trend in pollen diagrams. However, it can be
259 clearly detected (e.g. increases of *Artemisia*, Poaceae, Chenopodiaceae, *Ephedra*, and/or forest
260 depletions) in the Sierra de Geres of northern Portugal (Ramil-Rego et al. 1998), Lagoa Lucenza
261 (Muñoz-Sobrino et al. 2001), Lagoa Lucenza (Santos et al. 2000), Pozo do Carballal (Muñoz-
262 Sobrino et al. 1997), the Cantabrian Lago Mayor del Valle (Allen et al. 1996), Alto de la Espina
263 (López-Merino 2009), and Lago Enol (López-Merino 2009), the Iberian Range sites of Hoyos de
264 Iregua (Gil-García et al. 2002), Quintanar de la Sierra (Peñalba et al. 1997, Ruíz-Zapata et al.
265 2002, 2003a), the Pyrenees (Montserrat 1992), Cataluña in Banyoles (Pérez-Obiol and Julià
266 1994), Sierra de Cabrera in La Roya, Sanabria Marsh (Allen et al. 1996), Sanguijelas and
267 Lleguna (Muñoz-Sobrino et al. 2004), Central Spain in Burgomillodo (Díez et al. 2002), and CC-
268 17 core in Tablas de Daimiel, La Mancha Plain (Dorado-Valiño et al. 2002, Valdeolmillos 2004);
269 Navarrés (Carrión and Dupré 1996, Carrión and van Geel 1999), Villena (Yll et al. 2003), and
270 Tossal de la Roca (Cacho et al. 1995) in eastern Spain, and characteristically Padul in the south
271 (Pons and Reille 1988). These, among other sites, represent a geographically wide spectrum of
272 sensitive sites to the Younger Dryas cold-dry period.

273 The response in the rest of the Lateglacial biozones is not so clear, although elements
274 are apparent in some high-resolution sequences. González-Sampériz et al. (2006) were able to

275 correlate the environmental changes observed in El Portalet peat bog in the Pyrenees with
276 several abrupt events observed in northern latitudes (Heinrich events 3 to 1, Oldest and Older
277 Dryas stades, Intra-Allerød Cold Period, and 8200 cal. yr BP event). The monumental work in
278 Serra da Estrela by van der Knaap and van Leeuwen (1997) is equally detailed at the
279 stratigraphical level, and show palynological changes, especially with *Quercus*, that fit into the
280 Greenland ice-core curves.
281
282 *UNEXPECTED SEQUENCES: absence of change, particular dynamics and threshold responses*
283 The former, expected, palaeobotanical records are representative of the commonest trends in
284 vegetation development throughout the Lateglacial and Early Holocene. They support the view
285 that vegetation changes during this interval were generally determined by rapid shifts in the
286 physical properties of the ecosystem. However, more than a few pollen sequences in
287 Mediterranean Spain fail to show persistent trends through time or correlate with the major events
288 described above (Fig. 1). Pollen-stratigraphical changes are episodic and abrupt, that is, they
289 occur on the time scales of decades to centuries. Moreover, some pollen records show millennial-
290 scale complacency to continental-scale climate change. All of these particular trajectories of
291 vegetation dynamics deserve attention, and it is our view they should be conceptualized even
292 when they may appear as less interesting or more inconclusive than the conventional histories
293 directly assignable to climatic changes.
294 The vegetation sequence of Navarrés shows developments in the southern valleys of the
295 Iberian System from about 30,900 to 3200 cal. yr BP (Carrión and van Geel, 1999) (Fig. 6). *Pinus*
296 forests dominated the glacial landscape and resisted invasion by other species until about 5900
297 cal. yr BP, even though *Quercus* and other temperate trees occurred in the region several
298 thousands of years before, as demonstrated by anthracological data (Badal et al.1994, Carrión-
299 Marco 2005). The variation of macro- and microcharcoal throughout the core suggests that *Pinus*

300 forests were only replaced by evergreen-*Quercus* scrub after local fire disturbance by the
301 Neolithic populations settled in the vicinity of the study site. Although a prevailing dry climate
302 during the first half of the Holocene may have played some role, our preferred interpretation of
303 this vegetation sequence is that millennial-scale inertia of the established *Pinus* forests was
304 followed by a threshold response to increased fire frequency and virulence.

305 Navarrés is not unique as a case of lateglacial and early Holocene dominance of pine
306 woodlands. In other pollen sequences, these may extend further in time by reaching the Late
307 Holocene, and this accounts for not only high- and mid-altitude mountain zones, but also coastal
308 territories and interior platforms (Fig. 1). Examples in the vicinity of Navarrés are San Benito
309 (Dupré et al. 1996) and Villena (Yll et al. 2003). In the Verdelpino cave pollen sequence, there is
310 no *Quercus* colonization during the Magdalenian (lateglacial) levels, and *Quercus* only increases
311 after c. 6000 cal. yr BP (López-García 1977). In El Carrizal, *Pinus* forests prevailed throughout
312 the Holocene with a minor, subsidiary component of broadleaved forests (Franco-Múgica et al.
313 2005). In Espinosa de Cerrato, the dominance of *Pinus* is still more prolonged (Franco-Múgica et
314 al. 2001) (Fig. 7). Similar records can be found in Gallocanta (Burjachs et al. 1996) and Ojos del
315 Tremedal in Montes Universales (Stevenson 2000). Charcoal analyses show the coexistence of
316 *Pinus nigra* and *P. halepensis* during the period c. 9900-8200 years BP in the rockshelter of Los
317 Baños (Teruel), and in La Cativera (Tarragona) (Allué 2002, Badal 2004).

318 Other cases are even more divergent from the expected trend. The pollen assemblage in
319 San Rafael shows that temperate trees and Mediterranean woody elements persisted during full
320 glacial times, without any evidence of xerophytization (Pantaleón-Cano et al. 2003). In contrast,
321 *Artemisia* increases from Lateglacial to Early Holocene. The optima of deciduous trees and
322 Mediterranean scrub (c. 7500-4500 cal. yr BP) occur later than the mesocratic early Holocene
323 phase of forest development in north-west Europe (Birks, 1986), and there is no record of any
324 lateglacial expansion of *Quercus*. San Rafael, therefore, shows out-of-phase relationships in

325 trends of meso- and xerophytic developments. Moreover, within the semi-arid southeastern
326 province, the patterns and timing of Holocene vegetation stages differ in San Rafael, and the
327 nearby Antas and Roquetas de Mar (Pantaleón-Cano 1997, Pantaleón-Cano et al. 2003), Elx
328 (Burjachs and Riera 1995), Salines (Burjachs et al. 1997), Gádor (Carrión et al. 2003),
329 Caldereros (Fuentes et al. 2005), Ubeda and Baeza (Fuentes et al. 2007), Carihuela (Fernández
330 et al. 2007), and Baza (Carrión et al. 2007) (Fig. 1). The difficulties with the correlation of
331 sequence events increase notably if we integrate charcoal records (Rodríguez-Ariza 1992, 2000).

332 In the Sierra de Segura, the Pleistocene-Holocene pollen record of Siles also exhibits its
333 own distinctiveness (Carrión 2002). There is a first increase of *Quercus* from c. 12,000 to 10,500
334 cal. yr BP, then it drops while *Pinus nigra* and *P. pinaster* increase and domain the landscape
335 until c. 7420 cal. yr BP, when deciduous *Quercus* invade abruptly the supramediterranean belt
336 (Fig. 13). Another atypical vegetation history is seen in Bajondillo, southern Mediterranean coast.
337 *Pinus, Quercus ilex, Betula* and *Abies* expand during the LGM and Lateglacial, while the onset of
338 the Holocene is characterized by a partial replacement of these taxa by *Alnus, Corylus, Fraxinus,*
339 *Ilex, Ulmus,* and *Quercus pyrenaica* type. The most important *Quercus* developments only occur
340 after c. 7500 cal. yr BP (Cortés-Sánchez et al. 2008). The pollen spectra from Bajondillo,
341 however, might be strongly influenced by the vicinity of the southeastern Baetic mountains. In
342 charcoal analyses of similarly thermic areas of Mediterranean Iberia, tree species such as *Abies,*
343 *Corylus* and *Betula* have so far not been identified (Rodríguez-Ariza 1992, 2000; Badal 1998).
344 Although they do not go back to the very onset of the Holocene, the Early-Late Holocene pollen
345 sequences of Algendar in Menorca (Yll et al. 1997) (Fig. 10) and Albufera de Alcudia in Mallorca
346 (Burjachs et al. 1994) show very particular vegetation dynamics since about 7800 cal. yr BP, with
347 *Juniperus, Pinus, Buxus* and *Corylus* as main protagonists.

348 Most of the cases described as “unexpected” lie in the Mediterranean Region, although in
349 very different physiographic contexts (Fig. 1). As in the present, landscape heterogeneity could

350 explain the occurrence of different vegetation types and moderate time lags in the response to
351 climatic changes. When a primary climatic control is provided though, there should be certain
352 overlap in the timing as well as in the palaeoclimatic significance of major events. Is it therefore
353 possible that early Holocene vegetation developments were influenced by the composition and
354 structure of the former plant communities? Could the cases of early-Holocene prevalence of
355 pines be associated to areas where well-structured pine forests featured in the lateglacial and /or
356 full-glacial landscapes? In general, pines show great phenotypic plasticity and resistance to
357 invasion due to a set of ecophysiological characteristics that make them competitive in stressful
358 environments (Rubiales et al. 2009). Facilitation is another plausible factor of species
359 replacement, and there are case studies with *Quercus* vs. *Pinus* (Gómez-Aparicio et al. 2005,
360 Gómez-Aparicio & Canham 2008). The climatic factor cannot be neglected, in any case, because
361 the regions under the influence of Atlantic fronts show expected vegetation histories (Fig. 1).
362 Palaeoecologically, what is clearly different between the Eurosiberian and Mediterranean region
363 of Iberia is the full-glacial vegetation, with more mesothermophilous trees, and a greater
364 extension of pine woodlands in the latter than the former (Carrión et al. 2008).

365 Phytogeographical hotspots of the Iberian Peninsula and Balearic Islands, as postulated
366 by the cohesion of palaeobotanical, phylogeographical, and neoecological studies, all lie in the
367 Mediterranean Region (Médail and Diadema 2009). So the glacial situation would be more
368 complex in the Mediterranean, affecting not only the plants (Jiménez et al. 2004, Magri et al.
369 2006, Leroy and Arpe 2007, López de Heredia et al. 2007), but also the fauna (Gómez & Lunt
370 2007, Finlayson and Carrión 2007, Stewart and Dalén 2008), and yet not only at the population
371 but also to the community and ecosystem levels (Arroyo et al. 2008). In this situation, subtle
372 differences in initial conditions during the full-glacial could have affected the outcome of post-
373 glacial events. In other words, due to the complex distribution and composition of forests during
374 the glacial phases, a simple postglacial picture of vegetation dynamics cannot be expected.

HUMANS AS AGENTS OF DISTURBANCE (AND MORE "UNEXPECTED PATHWAYS")

Climate has, doubtless, exerted an important influence on Holocene vegetation sequences of the Iberian Peninsula, above all into the Eurosiberian Region (Fig. 1). Palaeoecological records of the Atlantic territories exhibit directional changes suitable to correlation with the Greenland isotopic records (Mayewski et al. 2004). Thus, during the early Holocene up to 7800 cal. yr BP, pollen sequences depict at least two episodes of xerophytization paralleling the GH-11.2 and GH-8.2 events (Muñoz-Sobrino et al. 2007). The 8.2 ka cold event is also discernible in the Central Ebro River Basin where its magnitude provoked the hunter-gatherer groups to migrate to regions with more favourable conditions (González-Sampériz et al. 2009). The Cañada de la Cruz pollen record shows that the ecotones between high-elevation pine forests and xerophytic grassland-scrub have changed in altitude at least five times over the last 10,000 years, and do appear to be sensitive to temperature change, although this must be strongly related with wind exposure, continentality, and average climate xericity (Carrión et al. 2001a). These changes are synchronous with periods of abrupt oscillations and rapid transitions in the climates of north Africa and the Sahel (Gasse 2000), and the North Atlantic region (Lauritzen 1996). Aridification phases inferred from pollen ratios in Mediterranean Iberia have been established at c. 8400-7600, 5300-4200, 4300-3400, 2850-1730, and 1300-750 cal. yr BP (Jalut et al. 2000), in correlation with arid intervals at Tigalmamine, north Africa (Lamb et al. 1995). In addition, it has been shown in a number of sequences from southern Spain that the period from c. 7500-5200 cal. yr BP represents the mesophytic optimum and the period of lowest fire activity (Burjachs and Riera 1995, Pantaleón-Cano et al. 1997, Carrión 2002, Carrión et al. 2003, 2007). In contrast, the sites of Padul (Pons and Reille, 1988), and Elx and Salines (Burjachs et al., 1997) show early-Holocene (c. 11,500-8500 cal. yr BP) mesophyte maxima. Similar asymmetries are acknowledged in northern Iberia, from Galicia to the Cantabrian region (Muñoz-Sobrino et al. 2005), the Pyrenees and northeastern Spain (González-Sampériz et al. 2005, 2006). For

402 instance, pollen data from NW Spain (Allen et al. 1996, Muñoz-Sobrino et al. 2001, 2004) depict a
403 woodland expansion between 8000 and 2000 cal. yr BP, while the Cantabrian sequences show
404 two forest maxima at 8000-7500 and from 5000 cal. yr BP onwards, separated by a phase of
405 more open landscapes (Muñoz-Sobrino et al. 2005).

406 Regardless of the bioclimatic region, it appears, however, that the patterns of vegetation
407 change reach maximum complexity between the Mid- and Late Holocene, and although some
408 trends can be well-established for several territories, the timing of forest declines and expansions
409 are spatially uneven and cannot be solely explained by current differences in physical setting
410 (Carrión et al. 2000, Gil-Romera et al. 2009). Among the factors involved we need to consider the
411 role of anthropogenic disturbance, which no doubt was spatially heterogeneous. Burning,
412 pastoralism, and ploughing by agrarian and metallurgic societies, for instance, may have been
413 historically decisive and site-specific. It is perhaps significant that this heterogeneity of
414 environmental change increases from Mid to Late Holocene, which strongly suggests that human
415 activities have been of crucial importance to shape current landscapes.

416 Figure 8 shows the Holocene pollen sites in which anthropogenic disturbance has been
417 identified through palynological indicators and contextualized through the archaeological record.
418 The geography of impacted sites is puzzling for any period considered. Many outstanding pollen
419 sites show starting times of anthropogenic disturbance falling into the Neolithic period, such as
420 Villena (Yll et al. 2003), Navarrés (Carrión and van Geel 1999), and San Benito (Dupré et al.
421 1996) in the east; Puerto de los Tornos and Atxuri (Peñalba 1994), Mougás (Gómez-Orellana et
422 al. 1998), Monte Areo and Alto de la Espina (López-Merino 2009), Comeya (Jiménez-Sánchez et
423 al. 2003), Hoyos de Iregua (Gil-García et al. 2002) in the north; Azután (Bueno et al. 2002),
424 Barruecos (López-Sáez et al. 2005) and Dehesa Río Fortes (López-Sáez 2002) in central Iberia;
425 Cerro de la Horca (López-Sáez et al. 2007), Prazo (López-Sáez et al. 2007), Muge Valley (van
426 der Schriek et al. 2007), and Charco da Candieira (van der Knaap and van Leeuwen 1994, 1995,

427 1997) in Portugal and the southwest; Bajondillo (Cortés-Sánchez et al. 2008), and Carihuela
428 (Fernández et al. 2007) in southern Spain; Cala´n Porter (Yll et al. 1997) (Fig. 10) and Albufera
429 de Alcudia (Burjachs et al. 1994) in the Balearic Islands. Anthracological and palaeocarpological
430 information confirms this early influence of man for the same regions (Uzquiano 1992a, Figueiral
431 1993, Buxó 1997, Rodríguez-Ariza 1992, 1995; Zapata 2002, Zapata et al. 2004, López-García
432 et al. 2003, Carrión-Marco 2005, Peña-Chocarro et al. 2005, Piqué 2005, Badal et al. 2008).
433 Charcoal of evergreen *Quercus*, present in north Atlantic Iberia, from Neolithic to Bronze Age
434 levels of archaeological sites, has been interpreted as the result of human action (Zapata 2002).
435 It must be emphasized though that the degree of landscape change that was clearly caused by
436 human activities during the early Neolithic is low, difficult to detect, and not free from controversy
437 (Carrión et al. 2007, López-Merino 2009).
438 The establishment of "cultural landscapes" during the expansion of metallurgical
439 communities (Fig. 8) is clearly depicted in pollen diagrams. Thus, during the Chalcolithic and
440 Bronze-Age cultural periods, many sites in the Iberian Peninsula show vegetation changes more
441 or less correlated with the timing of disturbances by humans. Several examples are Can Roqueta
442 (Burjachs and Expósito 2007), Lago Enol (López-Merino 2009, Moreno et al., in press), Pozo do
443 Carballal (Muñoz-Sobrino et al. 2007), San Isidro (Fombella Blanco et al. 2003), and
444 Tramacastilla (Montserrat 1992) in the north; Carril de Caldereros (Fuentes et al. 2005), and
445 Cova 120 (Burjachs 1988) in eastern Spain; Rascafría (Ruíz-Zapata et al. 2006), El Portalón
446 (Ruíz-Zapata et al. 2003b), and Covatilla (Atienza 1995) in central Spain; Melides (Santos et al.
447 2002) in Portugal; Acebrón (Stevenson and Harrison 1992) (Fig. 11), Las Madres (Stevenson
448 1985), Medina (Reed et al. 2001), Baza (Carrión et al. 2007), Gádor (Carrión et al. 2003), Baeza
449 and Úbeda (Fuentes et al. 2007) in southern Spain, and Algendar in Minorca (Yll et al. 1997) (Fig.
450 9). Again, this thesis is supported by anthracological and palaeocarpological information related
451 with archaeological surveys (Grau 1990, Rodríguez-Ariza and Vernet 1991, Rodríguez-Ariza

1995, 2000, Buxó 1997, Cámalich and Martín 1999, Castro et al. 1999, Carrión-Marco 2004, 2005, García and Grau 2005, Allué et al. 2006; García et al. 2007, Ros Sala 2008).

Many of the former sites continue to be affected by anthropogenic degradation during Iron Age times, the Romanization and episodes of the last centuries. However, other pollen sites only show anthropogenic indicators after Roman times, or even only during the last centuries (Fig. 8). Alteration usually includes human-set fires often combined with overgrazing, opening of the landscapes, spread of grasslands, thorny scrub and junipers in altitude, depletion of mesophytes, increases of heaths in the Eurosiberian Region, and garrigas in the Mediterranean Region, loss of arboreal diversity and increase of heliophytic herbs. Sites like El Sabinar (Carrión et al. 2004), Siles (Carrión 2002), Daimiel (Gil-García et al. 2007), El Carrizal (Franco-Múgica et al. 2005), Espinosa de Cerrato (Franco-Múgica et al. 2001) (Fig. 7), Villaviciosa (García-Antón et al. 2006), and Leitariegos (García-Rovés et al. 2001) show these first impacts only during the last two millennia. Others, like Cañada de la Cruz (Carrión et al. 2001b), Lucenza (Santos et al. 2000), Quintanar de la Sierra (Ruíz-Zapata et al. 2002), and Villuercas (Gil-Romera et al. 2008), register human influences even later. In fact, it is remarkable that some pollen sequences lack anthropogenic pollen indicators (Pantaleón-Cano et al. 2003), and that others correspond primarily to climate changes, in spite of the noted influence of humans (e.g. Taravilla Lake by Moreno et al. 2009).

Aiming to find out whether altitude would play an important role in the distribution of sites, a frequency analysis was carried out (Fig. 9). In order to reduce the bias produced by the dissimilar abundance of sites at different altitudes, the frequency of sites in every period at any specific altitude was weighted by the abundance of total sites in that particular altitude belt. Thus the frequency is not conditioned by the number of sites found for a period but only for the altitude. According to the frequency distribution, the Iberian Peninsula shows plentiful sites with Neolithic impact of man on the vegetation landscapes, probably because of the early development of

477 agriculture. However, the antiquity of their pastoral practices would have also demanded the
478 occupation of rich, fresh high altitude grasslands. Within the Mediterranean Region, the sites with
479 evidence of Chalcolithic-Bronze impacts occur largely below the oromediterranean belt, in regions
480 that, at the time, were probably cooler and wetter than nowadays. These would represent suitable
481 ecological conditions since they were probably providing the resources needed for the
482 intensification of mining and agricultural activities while avoiding unnecessary risk and hazards
483 derived from mountain occupation and facilitating the access to resources given the low altitudes.
484 Since the Roman period onwards the land was widely occupied but, while occupying lowlands
485 sites, the higher mountain belts were also populated.

486 The history of the vegetation of a number of sites seems clearly influenced by changes in
487 local economy, but there remain technical difficulties in establishing a causal relationship between
488 cultural and environmental changes given the imprecise chronologies available and the
489 fragmentary character of most of the palaeoecological information. One exception is the study
490 carried out in Sierra de Baza and Sierra de Gádor regarding the Argaric culture collapse that took
491 place sharply about c. 3600 cal. yr BP (Carrión et al. 2003, 2007) (Fig. 12). From the fourth to the
492 first half of the third millennia BC in southeastern Spain, the economy was a subsistence one
493 based on mixed pastoral-agricultural strategies. Subsequently, mining is associated with a
494 population increase during the third millennium and throughout the greater part of the second
495 millennium BC. It is the beginning of the first metallurgic communities of the south-eastern
496 Peninsula: the cultures of the Chalcolithic Los Millares and the Argaric Bronze. From the end of
497 the second millennium to the Late Roman-High Medieval period, there is a depopulation that
498 coincides with the disappearance of the Argaric world and copper-bronze-arsenic metallurgy. The
499 palynological sequences of Baza (Carrión et al. 2007), Gádor (Carrión et al. 2003), Caldereros
500 (Fuentes et al. 2005), in conjunction with other fragmentary palaeobotanical information (Carrión
501 et al. 2007) suggest ecological degradation, landscape opening, fires, pastoralism, and perhaps

502 tree cutting for mining, as the proximate causes of abandonment (Fig. 12). In the southwest
503 Iberian Peninsula, evidence of ecological degradation has been detected from the Chalcolithic. In
504 the beginning of the third millennium BC, intensive copper mining and smelting developed in the
505 Iberian Pyrite Belt of southwestern Spain (Nocete al. 2005). It was of great magnitude and
506 provoked systematic deforestation and increased erosion and the beginnings of heavy metal
507 pollution in the estuaries of Tinto and Odiel rivers (Gulf of Cádiz). Based on a temporal correlation
508 between the developments and dismantling of territorial networks, Nocete et al. (2005) have
509 inferred a direct link to the development and collapse of the intersocial body of Core/Periphery
510 relationships during this cultural period.
511 In northern and northwestern Iberia, Muñoz-Sobrino et al. (2005) and López-Merino
512 (2009) found evidence of minor Neolithic-induced transformations, but the Chalcolithic, Bronze,
513 Iron, and Roman phases are most often characterized by profound impacts on the forests,
514 probably linked to the increase of surfaces for agriculture and livestock grazing. Forest clearance,
515 probably linked to mining is also noticed in the Cantabrian region. More recently, a major
516 reforestation occurred during the Christian Reconquest and the associated repopulation of the
517 north. Other pulses of population growth include the 12th and 13th centuries (Valdeón et al. 1994)
518 and the Late Middle Ages until the 16th century, in which the reactivation of economy was based
519 on sheep/goat production. Deforestation increased during the 16th century due to the demand of
520 wood for large ship construction during the Spanish colonization of America (Muñoz-Sobrino et al.
521 2005, and Valbuena et al., in this volume). The last five thousands years have certainly been of
522 great impact, by human economic activity, on the vegetation landscapes of northern Iberia.
523 The intensity and timing of human impact on vegetation have varied from one part of the
524 Iberian Peninsula to another. In one sense, human activities are a further “unexpected” pathway
525 influencing vegetation dynamics. Changes in demography and economic activities represent
526 historical accidents which may provoke peculiar trajectories in vegetation history, such as seen in

527 the Balearic Islands of Mallorca and Minorca (Fig. 10). Yet, the interpretation of pollen-
528 stratigraphical changes as a result of local human disturbance may be speculative if due account
529 is not taken of the spatial scale of the impact, and of the other physical and biotic influences. How
530 climate, ecological factors, and man activities may interact to produce similarities and
531 divergences in Holocene vegetation sequences is illustrated in the Segura Mountains of southern
532 Spain. Comparison between the main vegetation shifts in the sites of Cañada de la Cruz, Siles,
533 Sabinar, and Villaverde depicts climatically-induced altitudinal displacements of vegetation belts
534 (Carrión 2002, Carrión et al. 2001b, 2004). However, altitudinal correlation of these taxa is
535 complicated by species interactions, mainly competitive and successional processes among
536 *Pinus nigra, P. pinaster*, deciduous and evergreen *Quercus* (Carrión 2002). A detailed revision of
537 the patterns and processes of vegetation change in Siles (Fig. 13) may provide us with a
538 corollary: climate has, doubtless, exerted long-term control of the species pool, but initiating
539 factors and the inertia of established tree populations, as well as migrational processes
540 interconnected with competition adjustments, were responsible for important time lags in the
541 response of vegetation to climate. Yet, fire disturbance would have been a major factor shaping
542 interspecific relationships and vegetation change from about 4500 cal. yr BP onwards.
543 Interestingly, the most obvious anthropogenic phase between 3000 and 1500 cal. yr BP
544 corresponds with maximum fire activity and great sensitivity in the vegetation, as could be
545 deduced from the rate-of-change curves (Carrión 2002).

546 Among all disturbances shaping the Iberian vegetation through time, the influence of fire
547 is probably the best understood. Fire is now considered an inherent element in the Mediterranean
548 environment, rejuvenating the system and generating new open spaces to be colonized (Carrión-
549 Marco 2005, Ojeda et al. 2005, Pausas & Keeley 2009). As stated in the introduction,
550 understanding the long-term role of fire would allow us to recognize the vegetation response to
551 different forcings. The analyses of past fire regimes, although slowly gaining more importance

552 across Europe and North-America (Carcaillet et al. 2001, 2007, Gavin et al. 2006, Tinner et al.
553 2006, Anderson et al. 2008, Higuera et al. 2008), are still very much needed in the southern
554 European Peninsulas (Vannière et al. 2008), where both the climate and the pattern of human
555 occupation create a unique fire-prone environment. Fire history reconstruction would help in
556 assessing the post-fire response of pines and oaks, as resprouters or seeders, as this might have
557 been a determinant factor of the ecosystem's resilience and for the competitive relation of
558 broadleaved and coniferous forests. Fire is intimately connected to fuel availability, moisture
559 patterns and therefore to climate changes, but it is also directly linked to human activities. This is
560 particularly well studied in the above-mentioned sequences of the south-eastern region of Iberia
561 (e.g. Carrión et al. 2001a-b, 2003, 2007), where the fire pattern is often independent from the
562 climate trends and it is more subject to the abandonment and reoccupation of different areas.
563 As we gain more taxonomic detail and stratigraphic resolution in pollen sequences of the
564 Iberian Peninsula, the prevailing climatic paradigm seems increasingly fragile. Vegetation stages
565 recur in time because vegetation is subject to the consequences of physical laws and processes.
566 But particularities must be explained and, in the cases exposed here, it seems that they may
567 appear determined as much as by the biotic history as by abiotic site properties.
568
569 **CONCLUSIONS**
570
571 Long-term vegetation dynamics in the Iberian Peninsula are subject to control factors equivalent
572 to those prevailing in Northern Europe. Its landscape diversity, ecological history, fire activity and
573 ancient human occupation, however, have often defined unexpected vegetation responses,
574 especially in the Mediterranean-influenced climate region. Recapitulating our initial hypothesis
575 about Iberian forest reactivity to climate change and human agency we highlight the following
576 aspects:

- In the Eurosiberian, and often also in the Mediterranean region of the Iberian Peninsula, the Lateglacial and early Holocene are characterized by the development of *Quercus*–dominated assemblages and other angiosperm trees at the expense of pine woodlands and steppes. The earliest *Quercus* invasions occur in coastal, oceanic and thermic regions. Mesophytic maxima take place most often during the first Holocene millennia. Continental and high-altitude locations reflect pine prevalence during this period. In those sites with sufficient stratigraphical resolution, the Younger Dryas cold spell is recorded in the form of expansion of xerophytes.
- In the Mediterranean Region, a millennial-scale resilience of the established forests is often observed. Occasionally, this resilience was followed by a threshold response to increased burning in the form of competitively-mediated *Quercus* invasion during the Mid Holocene. In other cases, the *Pinus* woodlands remained as dominant landscapes until the Late Holocene or present day. Vegetational dynamics in the Balearic Islands are diverse and strongly dependent on the floristic composition and human activities.
- Human occupation has played a determinant role shaping the Iberian landscapes as we know them since the Mid-Holocene; grazing, agriculture, mining, coppicing, slash and burn, etc., are all activities exerting deep transformations. As for the climate forcing, anthropogenically induced changes have had, sometimes, unpredictable consequences and complicate the climatic reconstructions.
- As we gain temporal resolution in pollen records, we can see the concentration of the major changes into relatively short episodes; the rate of change is definitively uneven, which points to the need of a conceptualization based in an historical-contingent rather than a deterministic approach.
- In the overall picture, some areas have always been more very sensitive to climate fluctuations and human activities, although the spatial pattern is puzzling. Independent of

602 the area, climate has exerted long-term control of the species pool, but initiating factors
603 and the inertia of established tree populations, as well as migrational processes
604 interconnected with competition adjustments, were responsible for important time delays
605 in the response of vegetation. This is so to such an extent that vegetation trajectories are
606 sometimes intricate enough as to predict that historical contingency overwhelms the
607 common trend. The need for more long-term vegetation studies is still very much needed
608 in order to understand the time lags between the three-fold forcing system: climate-
609 vegetation-humans.
610

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617

618 ## References

619 Agustí, B., Alcalde, G., Burjachs, F., Buxó, R., Juan-Muns, N., Oller, J., Ros, M.T., Rueda, J.M.,
620 Toledo, A., 1987. Dinàmica de la utilització de la Cova 120 per l'home en els darrers
621 6.000 anys. Sèrie monogràfica, 7. Centre d'Investigacions Arqueològiques de Girona
622 (CIAG). Diputació de Girona.
623 Allen, J.R., Huntley, B., Watts, W., 1996. The vegetation and climate of northwest Iberia over the
624 last 14000 yr. Journal of Quaternary Science 11(2), 125-147.
625 Allué, E., 2002. Dinámica de la vegetación y explotación del combustible leñoso durante el
626 Pleistoceno Superior y el Holoceno del noreste de la Península Ibérica a partir del
627 análisis antracológico. Ph.D. thesis, Universitat Rovira i Virgili, Tarragona.
628 Allué, E., Euba, I., Alarcos, A., González Jiménez, R., Martínez Rodríguez, P., 2006. Noves
629 aportacions al coneixement del medi vegetal i l'explotació del combustible durant el
630 Bronze final a partir de l'anàlisi antracològica de Sta. Digna III (Llerona, Les Franqueses
631 del Vallès). Cypsela 16, 177-181.

632 Anderson, R.S., Allen, C.D., Toney, J.L., Jass, R.B., Bair, A.N., 2008. Holocene vegetation and
633 fire regimes in subalpine and mixed conifer forests, southern Rocky Mountains, USA.
634 International Journal of Wildland Fire 17, 96-114.

635 Andrade, A., 1995. Dinámica de la vegetación, durante los últimos 3.000 B.P., en las Sierras de
636 La Paramera, La Serrota y Villafranca (Ávila), a partir del análisis polínico. Ph.D. thesis,
637 Universidad de Alcalá de Henares.

638 Andrade, A., Ruiz, B., 1993. Dinámica de la vegetación actual y aplicación de su espectro
639 polínico en la reconstrucción de la paleovegetación en la Sierra de la Paramera (Ávila,
640 España). Geogaceta 13, 7-11

641 Arroyo, J., Carrión, J.S., Hampe, A., Jordano, P., 2008. La distribución de las especies en
642 diferentes escalas espacio-temporales. In: Valladares, F. (Ed.), Ecología del bosque
643 mediterráneo en un mundo cambiante. Ministerio de Medio Ambiente, Madrid, pp. 29-70.

644 Atienza, M., 1995. Estudio palinológico de los cambios en el límite superior del bosque durante el
645 Holoceno en la Sierra de Béjar. Sistema Central Español. In: Aleixandre Campos, T.,
646 Pérez González, A. (Eds.), Reconstrucción de paleoambientes y cambios climáticos
647 durante el Cuaternario. Monografías 3. Centro de Ciencias Medioambientales, C.S.I.C.,
648 Madrid, pp. 329-338.

649 Aura Tortosa, J.E., Carrión-Marco, Y., García Puchol, O., Jardón Giner, P., Jordá Pardo, J.F.,
650 Molina Balaguer, L., Morales Pérez, J.V., Pascual Benito, J.L., Pérez Jordá, G., Pérez
651 Ripoll, M., Rodrigo García, M.J., Verdasco Cebrián, C.C., 2006. Epipaleolítico-Mesolítico
652 en las comarcas centrales valencianas. In: Alday Ruiz, A. (Ed.), El Mesolítico de
653 muescas y denticulados en la cuenca del Ebro y el litoral mediterráneo peninsular.
654 Diputación Foral de Álava, Departamento de Cultura, Álava, pp. 65-120.

655 Badal, E., 1998. El interés económico del pino piñonero para los habitantes de la Cueva de
656 Nerja. In: Sanchidrían Torti, J.L., Simón Vallejo, M.D. (Eds.), Las culturas del Pleistoceno
657 Superior en Andalucía. Patronato de la Cueva de Nerja. Málaga, pp. 287-299.

658 Badal, E., 2004. Análisis antracológico de los restos del fuego doméstico del abrigo de los Baños
659 (Ariño, Teruel). In: Utrilla, P., Rodanés, J.M. (Eds.), Un asentamiento epipaleolítico en el
660 valle del río Martín. El abrigo de Los Baños (Ariño, Teruel). Monografías Arqueológicas,
661 vol. 39. Universidad de Zaragoza, pp. 63-73.

662 Badal, E., 2006. Carbones y cenizas, ¿qué nos cuentan del pasado?. In: Carrión, J.S.,
663 Fernández, S., Fuentes, N. (Coords.), Paleoambientes y cambio climático. Fundación
664 Séneca. Agencia de Ciencia y Tecnología de la Región de Murcia, pp. 103-116.

665 Badal, E., Bonet, H., Collado, E., Fabado, J., Fuentes, M., Izquierdo, I., Mata, C., Moreno, A.,
666 Ntinou, M., Quixal, D., Ripollès, P.P., Soria, L., 2008. Lo real y lo imaginario. El proyecto
667 Hum2004-04939 sobre la flora en el mundo Ibérico. In: Rovira, S., García-Heras, M.,
668 Gener, M., Montero, I. (Eds.), Actas VII Congreso Ibérico de Arqueometría, Madrid, pp.
669 144-157.

670 Badal, E., Bernabeu, J., Vernet, J.L., 1994. Vegetation changes and human action from the
671 Neolithic to the Bronze Age (7000-4000 B.P.) in Alicante, Spain, based on charcoal
672 analysis. Vegetation History and Archaeobotany 3, 155-166.

673 Bennett, K.D., Willis, K.J., 1995. The role of ecological factors in controlling vegetation dynamics
674 on long temporal scales. Giornale Botanico Italiano 129, 243-254.

675 Bergadà, M., Burjachs, F., Fullola, J.M., 1999. Évolution paléoenvioronnemental du 14.500 au
676 10.000 BP dans le Prépyrénées catalans: La Grotte du Parco (Alòs de Balaguer, Lleida,
677 Espagne). L'Anthropologie 103(2), 249-264.

678 Bhagwat, S.A., Willis, K.J., 2008. Species persistence in northerly glacial refugia of Europe: a
679 matter of chance or biogeographical traits? Journal of Biogeography 35, 464-482.

680 Birks, H.J.B., 1986. Late Quaternary biotic changes in terrestrial and lacustrine environments,
681 with particular reference to north-west Europe. In: Berglund, B.E. (Ed.), Handbook of
682 Holocene palaeoecology and palaeohydrology. Wiley, Chichester, pp. 3-65.

683 Bradley, R.S., 2008. Holocene perspectives on future climate change. In: Battarbee, R.W.,
684 Binney, H.A. (Eds.), Natural Climate Variability and Global Warming: a Holocene
685 Perspective. Wiley-Blackwell, Chichester, pp. 254-268.

686 Brewer, S., Cheddadi, R., de Beaulieu, J.L., Reille, M., 2002. The spread of deciduous *Quercus*
687 throughout Europe since the last glacial period. Forest Ecology and Management 156,
688 27-48.

689 Bueno, P., Barroso, R., Balbín, R., Campo, M., Exteberría, F., González, A., Herrasti, L.,
690 Treserras, J.J., López-García, P., López-Sáez, J.A., Matamala, J.C., Sánchez, B., 2002.
691 Áreas habitacionales y funerarias en el Neolítico de la cuenca interior del Tajo: la
692 provincia de Toledo. Trabajos de Prehistoria 59(2), 65-79.

693 Burjachs, F., 1988. Análisis polínico de los niveles cerámicos de la "Cova 120" (Alta Garrotxa,
694 Catalunya). Acta Salmanticensia 65, 285-290.

695 Burjachs, F., 1994. The palynology of the upper Pleistocene and Holocene of the North East
696 Iberian Peninsula: Pla de l'Estany (Catalonia). Historical Biology 9, 17-33.

697 Burjachs, F., 1996. La secuencia palinológica de La Cruz (Cuenca, España). XI Simposio de
698 Palinología (A.P.L.E.). Universidad de Alcalá. Estudios Palinológicos. Madrid, pp. 31-36.

699 Burjachs, F., 1997. L'entorn de l'assentament. Reconstitució del paisatge vegetal i el clima. In:
700 Alcalde, G., Molist, M., Saña, M., Toledo, A. (Eds.), Procés d'ocupació de la bauma del
701 Serrat del Pont (La Garrotxa) entre el 2900 i el 1450 cal. A.C.. Publicacions Eventuals
702 d'Arqueologia de la Garrotas, vol. 2. Museu Comarcal de la Garrotas, Olot, pp. 13-18, 41-
703 43, 61-63 i 77-80.

704 Burjachs, F., 1998. Análisis polínico del poblado protohistórico de Genó (Aitona, El Segrià). In:
705 Maya, J.L., Cuesta, F., López Cachero, J. (Eds.), Genó: Un poblado del Bronze Final en
706 el Bajo Segre (Lleida). Publicacions de la Universitat de Barcelona. Barcelona, pp. 175-
707 186.

708 Burjachs, F., 2004. Paisatges i climes medievals de la façana ibèrica nord-occidental. In: Rueda,
709 J.M., Tura, J. (Eds.), Actes del Congrés Els castells medievals a la Mediterrània Nord-
710 Occidental. Museu Etnològic del Montseny, Arbúcies, pp. 231-246.

711 Burjachs, F., 2009. Paleoambient del Tardiglacial al sud dels Pirineus vist a través de la
712 Palinologia. Publicació de la ponència al XIV Col·loqui Internacional d'Arqueologia de
713 Puigcerdà: El Pirineu i les àrees circumdants durant el Tardiglacial. Mutacions i filiacions
714 tecnoculturals, evolució paleoambiental. Museu Cerdà. (10-11 novembre 2006),
715 Puigcerdà, in press.

716 Burjachs, F., Renault-Miskovsky, J., 1992. Paléoenvironnement et paléoclimatologie de la
717 Catalogne durant pres de 30000 ans (du Würmien ancien au début de l'Holocène)
718 d`apres la palynologie du site de l`Arbreda (Gerone, Catalogne). Quaternaire 3(2), 75-85.

719 Burjachs, F., Riera, S., 1995. Canvis vegetals i climàtics durant el Neolític a la façana
720 mediterrània ibèrica. Rubricatum 1, 21-27.

721 Burjachs, F., Expósito, I., 2007. 4.2.2. El paisatge vegetal. In: Carlús, X., López-Cachero, F.J.,
722 Oliva, M., Palomo, A., Rodríguez Lázaro, A., Terrats, N., Lara, C., Villena, N. (Eds.),
723 Cabanes, sitges i tombes: El paratge de Can Roqueta (Sabadell, Vallès Occidental) del
724 1300 al 500 AC. Quaderns d'Arqueologia 4. Museu d'Història de Sabadell, Ajuntament
725 de Sabadell, Sabadell, pp. 72-73.

726 Burjachs, F., Pérez-Obiol, R., Roure, J.M., Julià, R., 1994. Dinámica de la vegetación durante el
727 Holoceno en la isla de Mallorca. In: Mateu, I., Dupré, M., Güemes, J., Burgaz, M.E.
728 (Eds.), Trabajos de Palinología básica y aplicada. Universitat de València, València, pp.
729 199-210.

730 Burjachs, F., Comín, F., Rodó, X., 1996. Gallocanta: ejemplo de secuencia palinológica en una
731 laguna efímera. In: Ruiz-Zapata, B. (Ed.), Estudios Palinológicos. Servicios de
732 Publicaciones de la Universidad de Alcalá, Alcalá de Henares, pp. 25-29.

733 Burjachs, F., Giralt, S., Roca, J.R., Seret, G., Julià, R., 1997. Palinología holocénica y
734 desertización en el Mediterráneo occidental. In: Ibáñez, J.J., Valero, B.L., Machado, C.
735 (Eds.), El paisaje mediterráneo a través del espacio y del tiempo. Implicaciones en la
736 desertificación. Geoforma Editores, Logroño, pp. 379-394.

737 Burjachs, F., Blech, M., Marzoli, D., Julià, R., 2000. Evolución del paisaje vegetal en relación con
738 el uso del territorio durante la edad del Hierro en el NE de la Península Ibérica. In:
739 Buxó,R., Pons, E. (Eds.), Els productes alimentaris d'origen vegetal a l'edat del Ferro de
740 l'Europa occidental: de la producció al consum. Sèrie Monogràfica, vol. 18. Publicacions
741 del Museu d'Arqueologia de Catalunya, Girona, pp. 31-42.

742 Buxó, R., 1997. Arqueología de las plantas. La explotación económica de las semillas y los frutos
743 en el marco mediterráneo de la Península Ibérica. Crítica, Barcelona. 367 pp.

744 Cabanes, D., Burjachs, F., Expósito, I., Rodríguez, A., Allué, E., Euba, I., Vergès, J.M., 2009.
745 Formation processes through archaeobotanical remains: The case of the Bronze Age
746 levels in El Mirador cave, Sierra de Atapuerca, Spain. Quaternary International 193(1-2),
747 160-173.

748 Cacho, C., Fumanal, M.P., López-García, P., López-Sáez, J.A., Pérez Ripoll, M., Martínez Valle,
749 R., Uzquiano, P., Arnanz, A., Sánchez Marco, A., Sevilla, P., Morales, A., Roselló, E.,
750 Garralda, M.D., García Carrillo, M., 1995. El Tossal de la Roca (Vall d' Alcalá, Alicante).
751 Reconstrucción paleoambiental y cultural de la transición del Tardiglaciar al Holoceno
752 inicial. Recerques del Museu d'Alcoi 4, 11-101.

753 Cámalich, M.D., Martín, D., 1999. El territorio almeriense desde los inicios de la producción hasta
754 fines de la antigüedad. Un modelo: la Depresión de Vera y Cuenca del Río Almanzora.
755 Arqueología, Monografías, Junta de Andalucía, Sevilla.

756 Carcaillet, C., Bergeron, Y., Richard, P.J.H., Frechette, B., Gauthier, S., Prairie, Y.T., 2001.
757 Change of fire frequency in the eastern Canadian boreal forests during the Holocene:
758 does vegetation composition or climate trigger the fire regime? Journal of Ecology 89,
759 930-946.

760 Carcaillet, C., Bergman, I., Delorme, S., Hornberg, G., Zackrisson, O., 2007. Long-term fire
761 frequency not linked to prehistoric occupations in northern Swedish boreal forest.
762 Ecology 88, 465-477.

763 Carrión-Marco, Y., 2003. Afinidades y diferencias en las secuencias antracológicas en las
764 vertientes mediterránea y atlántica de la Península Ibérica. Ph.D. thesis, Universitat de
765 València, Valencia.

766 Carrión-Marco, Y., 2004. Análisis antracológico del yacimiento de Fuente Álamo (Cuevas del
767 Almanzora, Almería): usos de la madera y paleovegetación. In: Hernández, L.,
768 Hernández, M. (Eds.), Congreso sobre la Edad del Bronce en las tierras valencianas y
769 zonas limítrofes. Universidad de Alicante, pp. 477-486.

770 Carrión-Marco, Y., 2005. La vegetación mediterránea y atlántica de la península Ibérica. Nuevas
771 secuencias antracológicas. Trabajos Varios de S.I.P. (Servicio de Investigación
772 Prehistórica) 104. Diputación Provincial de Valencia, Valencia. 314 pp.

773 Carrión, J.S., 1990. Evolución paleoambiental durante el Pleistoceno Superior en el Sureste de
774 España. Las secuencias polínicas da las cuevas de la Carihuela (Granada) y Beneito
775 (Alicante). Ph.D. thesis. Universidad de Murcia, Murcia.

776 Carrión, J.S., 1992. Late Quaternary pollen sequence from Carihuela Cave, southeastern Spain.
777 Review of Palaeobotany and Palynology 71, 37-77.

778 Carrión, J.S., 2001a. Dialectic with climatic interpretations of Late-Quaternary vegetation history
779 in Mediterranean Spain. Journal of Mediterranean Ecology 2, 145-156.

780 Carrión, J.S., 2001b. Pastoreo y vulnerabilidad de la vegetación en la alta montaña mediterránea
781 durante el Holoceno. Cuadernos de Geografía 69/70, 7-22.

782 Carrión, J.S., 2002. Patterns and processes of Late Quaternary environmental change in a
783 montane region of southwestern Europe. Quaternary Science Reviews 21, 2047-2066.

784 Carrión, J.S., Dupré, M., 1996. Late Quaternary vegetational history at Navarrés, eastern Spain.
785 A two-core approach. New Phytologist 134, 177-191.

786 Carrión, J.S., van Geel, B., 1999. Fine-resolution Upper Weichselian and Holocene palynological
787 record from Navarrés (Valencia, Spain) and a discussion about factors of Mediterranean
788 forest succession. Review of Palaeobotany and Palynology 106, 209-236.

789 Carrión, J.S., Navarro, C., 2002. Cryptogam spores and other non-pollen microfossils as sources
790 of palaeoecological information: case-studes from Spain. Annales Botanici Fennici 39, 1-
791 14.

792 Carrión, J.S., Munuera, M., Navarro, C., Sáez, F., 2000. Paleoclimas e historia de la vegetación
793 cuaternaria en España a través del análisis polínico. Viejas falacias y nuevos
794 paradigmas. Complutum 11, 115-142.

795 Carrión, J.S., Andrade, A., Bennet, K.D., Navarro,C., Munuera, M., 2001a. Crossing forest
796 thresholds: inertia and collapse in a Holocene sequence from south-central Spain. The
797 Holocene 11(6), 635-653.

798 Carrión, J.S., Munuera, M., Dupré, M., Andrade, A., 2001b. Abrupt vegetation changes in the
799 Segura Mountains of southern Spain throughout the Holocene. Journal of Ecology 89,
800 783-797.

801 Carrión, J.S., Sánchez-Gómez, P., Mota, J.F., Yll, E.I., Chaín, C., 2003. Fire and grazing are
802 contingent on the Holocene vegetation dynamics of Sierra de Gádor, southern Spain.
803 The Holocene 13, 839-849.

804 Carrión, J.S., Willis, K.J., Sánchez Gómez, P., 2004. Holocene forest history of the eastern
805 plateaux in the Segura Mountains (Murcia, southeastern Spain). Review of Palaeobotany
806 and Palynology 132, 219-236.

807 Carrión, J.S., Fuentes, N., González-Sampériz, P., Quirante, L.S., Finlayson, J.C., Fernandez, S.,
808 Andrade, A., 2007. Holocene environmental change in a montane region of southern
809 Europe with a long history of human settlement. Quaternary Science Reviews 26, 1455-
810 1475.

811 Carrión, J.S., Finlayson, C., Férnández, S., Finlayson, G., Allué, E., López-Sáez, J.A., López-
812 García, P., Gil-Romera, G., Bailey, G., González-Sampériz, P., 2008. A coastal reservoir
813 of biodiversity for Upper Pleistocene human populations: Palaeoecological investigations
814 in Gorham's Cave (Gibraltar) in the context of the Iberian Peninsula. Quaternary Science
815 Reviews 27, 2118-2135.

816 Carrión, J.S., Fernández, S., Jiménez-Moreno, G., Fauquette, S., Gil-Romera, G., González-
817 Sampériz, P., Finlayson, C., 2009. The historical origins of aridity and vegetation
818 degradation in southeastern Spain. Journal of Arid Environments
819 doi:10.1016/j.jaridenv.2008.11.014

820 Castro, P.V., Chapman, R.W., Suriñach, S., Lull, V., Micó, R., Rihuete, C., Risch, R., Sanahuja,
821 M.E.,1999. Proyecto Gatas 2. La dinámica arqueoecológica de la ocupación prehistórica.
822 Arqueología, Monografías, Junta de Andalucía, Sevilla. 426 pp.

823 Conedera, M., Krebs, P., Tinner, W., Pradella, M., Torriani, D., 2004. The cultivation of *Castanea*
824 *sativa* (Mill.) in Europe, from its origin to its diffusion on a continental scale. Vegetation
825 History and Archaeobotany 13, 161-179.

826 Cortés Sánchez, M., Morales Muñiz, A., Simón Vallejo, M.D., Bergadà Zapata, M.M., Delgado
827 Huertas, A., López-García, P., López-Sáez, J.A., Lozano Francisco, M.C., Riquelme
828 Cantal, J.A., Roselló Izquierdo, E., Sánchez Marco, A., Vera Peláez, J.L., 2008.
829 Palaeoenvironmental and cultural dynamics of the coast of Málaga (Andalusia, Spain)
830 during the Upper Pleistocene and Early Holocene. Quaternary Science Reviews 27,
831 2176-2193.

832 Davis, B.A.S., Stevenson, A.C., 2007. The 8.2 ka event and early-mid Holocene forests, fires and
833 flooding in the Central Ebro Desert, NE Spain. Quaternary Science Reviews 26, 1695-
834 1712.

835 Davis, B.A.S., Stevenson, A.C., Juggins, S., Reed, J., Franco-Múgica, F., 2008. The 'Las
836 Encinas' Project. http://craticula.ncl.ac.uk/lasencinas/

837 Díez, A., Bateman, M.D., López-Sáez, J.A., Vegas, J., 2002. Procesos eólicos tardiglaciares en
838 la Submeseta septentrional: cronología del manto arenoso de la Tierra de Pinares. In:
839 Pérez, A., Vegas, J., Machado, M.J. (Eds.), Aportaciones a la geomorfología de España
840 en el inicio del Tercer Milenio. IGME–S.E.G., Madrid, pp. 167-175.

841 Dorado-Valiño, M., Valdeolmillos Rodriguez, A., Ruiz-Zapata, B., Gil-García, M.J., de Bustamante
842 Gutiérrez, I., 2002. Climatic changes since the Late-glacial/Holocene transition in La
843 Mancha Plain (South-central Iberian Peninsula, Spain) and their incidence on Las Tablas
844 de Daimiel marshlands. Quaternary International 93/94, 73-84.

845 Dupré, M., 1988. Palinología y paleoambiente. Nuevos datos españoles. Referencias. Servicio de
846 Investigación Prehistórica. Serie de Trabajos Varios, 84, Valencia.

847 Dupré, M., 1989. Análisis polínico de la Cueva de Amalda. In: Altuna, J., Valdeón, A.,
848 Mariezkurrena, K. (Eds.), La Cueva de Amalda (Zestoa, País Vasco). Ocupaciones
849 paleolíticas y postpaleolíticas. Eusko Ikaskuntza. Sociedad de Estudios Vascos, pp. 49-
850 51.

851 Dupré, M., Fumanal, M.P., Martínez Gallego, J., Pérez Obiol, R., Roure, J.M., Usera, J., 1996.
852 The Laguna de San Benito (Valencia, Spain): palaeoenvironmental reconstruction of an
853 endorheic system. Quaternaire 7(4), 177-186.

854 Fernández, S., Fuentes, N., Carrión, J.S., González-Sampériz, P., Montoya, E., Gil, G., Vega
855 Toscano, G., Riquelme, J.A., 2007. The Holocene and Upper Pleistocene pollen
856 sequence of Carihuela Cave, southern Spain. Geobios 40, 75-90.

857 Figueiral, I., 1993. Charcoal analysis and the vegetation evolution of northwest Portugal. Oxford
858 Journal Archaeology 12(2), 209-222.

859 Figueiral, I., 1995. Charcoal analysis and the history of *Pinus pinaster* (cluster pine) in Portugal.
860 Review of Palaeobotany and Palynology 89, 441-454.

861 Figueiral, I., Terral, J.F., 2002. Late quaternary refugia of Mediterranean taxa in the Portuguese
862 Estremadura: charcoal based palaeovegetation and climatic reconstruction. Quaternary
863 Science Reviews 21, 549-558.

864 Finlayson, C., Carrión, J.S., 2007. Rapid ecological turnover and its impact on Neanderthal and
865 other human populations. Trends in Ecology and Evolution 22(4), 213-222.

866 Fletcher, W.J., Boski, T., Moura, D., 2007. Palynological evidence for environmental and climatic
867 change in the lower Guadiana valley, Portugal, during the last 13000 years. The
868 Holocene 17(4), 481-494.

869 Fombella Blanco, M.A., García-Rovés, E., Puente, E., 2003. Comparative palynological analysis
870 between the San Isidro and Leitariegos Holocene sequences, NW Spain. Acta
871 Paleontologica Sinica 42(1), 111-117.

872 Franco-Múgica, F., García-Antón, M., Sainz Ollero, H., 1997. Impacto antrópico y dinámica de la
873 vegetación durante los últimos 2000 años BP en la vertiente septentrional de la Sierra de
874 Gredos: Navarredonda (Ávila, España). Revue de Paléobiologie 16(1), 29-45.

875 Franco-Múgica, F., García-Antón, M., Maldonado Ruiz, J., Morla Juaristi, C., Sainz Ollero, H.,
876 2001. The Holocene history of *Pinus* forest in the Spanish Northern Meseta. The
877 Holocene 11(3), 343-358.

878 Franco-Múgica, F., García-Antón, M., Maldonado Ruiz, J., Morla Juaristi, C., Sainz-Ollero, H.,
879 2005. Ancient pine forest on inland dunes in the Spanish Northern meseta. Quaternary
880 Research 63, 1-14.

881 Fuentes, N., García Martínez, M., González-Sampériz, P., Fernández, S., Carrión, J.S., Ros, M.,
882 López Campuzano, M., Medina, J., 2005. Degradación ecológica y cambio cultural
883 durante los últimos cuatro mil años en el sureste ibérico semiárido. Anales de Biología
884 27, 69-84.

885 Fuentes, N., Carrión, J.S., Fernández, S., Nocete, F., Lizcano Prestel, R., Pérez, C., 2007.
886 Análisis polínico de los yacimientos arqueológicos Cerro del Alcázar de Baeza y Eras del
887 Alcázar de Úbeda (Jaén). Anales de Biología 29, 85-93.

888 García-Antón, M., Franco-Múgica, F., Maldonado, J., Morla Juaristi, C., Sainz Ollero, H., 1997.
889 New data concerning the evolution of the vegetation in Lillo pinewood (León, Spain).
890 Journal of Biogeography 26, 929-934.

891 García-Antón, M., Gil Romera, G., Pagés, J.L., Alonso Millán, A., 2006. The Holocene pollen
892 record in the Villaviciosa Estuary (Asturias, North of Spain) in relation to changes in sea
893 level. Palaeogeography, Palaeoclimatology, Palaeoecology 237, 280-292.

García, M.S., Grau, E., 2005. Aprovechamiento de los recursos leñosos en la fase protohistórica de Punta de los Gavilanes (Mazarrón, Murcia). Anales de Prehistoria y Arqueología 21, 51-68.

García Martínez, M.S., Grau Almero, E., Ros Sala, M.M., 2007. Paisaje y gestión de los recursos vegetales en la costa de Mazarrón (Murcia), según el antracoanálisis de Punta de los Gavilanes. In: Lario, J., Silva, P. (Eds.), Contribuciones al estudio del período Cuaternario. AEQUA, Ávila, pp.107-108.

García-Amorena, I., Gómez Manzaneque, F., Rubiales, J.M., Granja, H.M., Soares de Carvalho, G., Morla, C., 2007. The Late Quaternary coastal forests of western Iberia; a study of their macroremains. Palaeogeography, Palaeoclimatology, Palaeoecology 254, 448-461.

García-Amorena, I., Morla, C., Rubiales, J.M., Gómez Manzaneque, F., 2008. Taxonomic composition of the Holocene forests of the northern coast of Spain, as determined from their macroremains. The Holocene 18, 819-829.

García-Rovés, E., Puente García, E., Fombella Blanco, M.A., Ruiz-Zapata, M.B., Marcos Varela, L., 2001. Primeros resultados palinológicos de la turbera del Puerto de Leitariegos, Provincia de León. In: Moreno Grau, S., Elvira Rendueles, B., Moreno Angosto, J.M. (Eds.), XIII Simposio de la Asociación de Palinólogos en Lengua Española (A.P.L.E.). Universidad Politécnica de Cartagena, Cartagena, pp. 283-290.

García-Rovés, E., 2007. Dinámica de la Paleovegetación y cambios climáticos durante el Tardiglaciar y Holoceno en secuencias sedimentarías de la provincia de León. Ph.D thesis, Universidad de León.

Gasse, F., 2000. Hydrological changes in the African tropics since the Last Glacial Maximum. Quaternary Science Reviews 19, 189-211.

Gavin, D.G., Hu, F.S., Lertzman, K., Corbett, P., 2006. Weak climatic control of stand-scale fire history during the Late Holocene. Ecology 87, 1722-1732.

Gil-García, M.J., Dorado-Valiño, M., Valdeolmillos Rodríguez, A., Ruiz-Zapata, M.B., 2002. Late-glacial and Holocene palaeoclimatic record from Sierra de Cebollera (northern Iberian Range, Spain). Quaternary International 93/94, 13-18.

Gil-García, M.J., Ruiz-Zapata, M.B., 2004. Desarrollo de la vegetación durante el Tardiglaciar y el Holoceno en la Sierra de Cameros (La Rioja. España). Implicaciones climáticas y antrópicas. Zubía 22, 237-250.

Gil-García, M.J., Ruiz-Zapata, M.B., Santisteban, J.I., Mediavilla, R., López-Pamo, E., Dabrio, C.J., 2007. Late Holocene environments in Las Tablas de Daimiel (south central Iberian peninsula, Spain). Vegetation History and Archaeobotany 16, 241-250.

Gil-Romera, G., García-Antón, M., Calleja Alarcón, J.A., 2008 The Holocene palaeoecological sequence of Serranía de las Villuercas in south-western Spain. Vegetation History and Archaeobotany 17, 653-666.

Gil-Romera, G., Carrión, J.S., McClure, S., Schmich, S., Finlayson, C., 2009. Holocene vegetation dynamics in Mediterranean Iberia: historical contingency and climate-human interactions. Journal of Anthropological Research 65, 271-285.

Giralt, S., Burjachs, F., Roca, J.R., Julià, R., 1999. Late Glacial to early Holocene environmental adjustment in the Mediterranean semi-arid zone of the Salines playa-lake (Alacant, Spain). Journal of Paleolimnology 21, 449-460.

937 Gómez, A., Lunt, D.H. 2007. Refugia within refugia: patterns of phylogeographic concordance in
938 the Iberian Penninsula. In: Weiss, S. y Ferrand, N. (editors), Phylogeography in southern
939 European refugia: evolutionary perspectives on the origins and conservation of European
940 biodiversity, Kluwer, Dordrecht, pp. 155-188.

941 Gómez-Aparicio, L., Canham, L.D., 2008. Neighborhood models of the effects of invasive tree
942 species on ecosystem processes. Ecological Monographs 78, 69-86.

943 Gómez-Aparicio, L., Gómez, J.M., Zamora, R., Boettinger, J.L., Ezcurra, E., 2005. Canopy vs.
944 soil effects of shrubs facilitating tree seedlings in Mediterranean montane ecosystems.
945 Journal of Vegetation Science 16, 191-198.

946 Gómez Lobo, A., Gil, M.J., Atienza, M., Ruiz-Zapata, M.B., 1996. Evolución de la
947 paleovegetación en el noroeste del Sistema Ibérico (Soria), durante los últimos 7000 BP.
948 Botanica Macaronesica 23, 233-240.

949 Gómez-Orellana, L., Ramil-Rego, P., Aira Rodríguez, M.J., 1996. Cronología y dinámica de los
950 humedales y lagunas existentes en las depresiones sedimentarias de Galicia. In: Ruiz-
951 Zapata, M.B., (Eds.), Estudios Palinológicos. Universidad de Alcalá de Henares, Alcalá
952 de Henares, pp. 63-68.

953 Gómez-Orellana, L., Ramil-Rego, P., Muñoz-Sobrino, C., 1998. Una nueva secuencia polínica y
954 cronológica para el depósito pleistoceno de Mougás (NW de la Península Ibérica). Revue
955 de Paléobiologie 17(1), 35-47.

956 Gómez Ortiz, A., Esteban Amat, A., 1993. Análisis polínico de la turbera de La Feixa (La Màniga,
957 Cerdanya, 2.150 m) .Evolución del paisaje. In: Fumanal, M.P., Bernabeu, J. (Eds.),
958 Estudios sobre Cuaternario, medios sedimentarios, cambios ambientales, hábitat
959 humano. Universitat de València, València, pp. 185-190.

960 González Porto, A.V., 1996. Estudio de la vegetación del Cuaternario en los Montes del Buio
961 (Lugo), a través del análisis polínico. Ph.D. thesis, Universidad de Vigo, Vigo.

962 González-Sampériz, P., 2004. Evolución paleoambiental del sector central de la cuenca del Ebro
963 durante el Pleistoceno Superior y Holoceno. Instituto Pirenaico de Ecología-CSIC,
964 Zaragoza. 210 pp.

965 González-Sampériz, P., Valero-Garcés, B.L., Carrión, J.S., Peña, J.L., García Ruiz, J.M.,
966 Sancho, C., Martí Bono, C., 2005. Glacial and lateglacial vegetation in northeastern
967 Spain: new data and a review. Quaternary International 140/141, 4-20.

968 González-Sampériz, P., Valero-Garcés, B.L., Moreno, A., Jalut, G., García-Ruiz, J.M., Martí-
969 Bono, C., Delgado-Huertas, A., Navas, A., Otto, T., Dedoubat, J.J., 2006. Climate
970 variability in the Spanish Pyrenees during the last 30,000 yr revealed by the El Portalet
971 sequence. Quaternary Research 66(1), 38-52.

972 González-Sampériz, P., Valero-Garcés, B.L., Moreno, A., Morellón, M., Navas, A., Machín, J.,
973 Delgado-Huertas, A. 2008. Vegetation changes and hydrological fluctuations in the
974 Central Ebro Basin (NE Spain) since the Late Glacial period: saline lake records.
975 Palaeogeography, Palaeoclimatology, Palaeoecology 259(2-3), 157-181.

976 González-Sampériz, P., Utrilla, P., Mazo, C., Valero-Garcés, B.L., Sopena, M.C., Morellón, M.,
977 Sebastián, M., Moreno, A., Martínez-Bea, M., 2009. Patterns of human occupation during
978 the early Holocene in the Central Ebro Basin (NE Spain) in response to the 8.2 ka
979 climatic event. Quaternary Research 71(2),121-132

980 Grau, E., 1990. El uso de la madera en yacimientos de la Edad del Bronze a época visigoda.
981 Datos etnobotánicos y reconstrucción ecológica según la antracología. Ph.D. thesis,
982 Universidad de Valencia, Valencia.

983 Hampe, A., Arroyo, J., Jordano, P., Petit, R.J., 2003. Rangewide phylogeography of a bird-
984 dispersed Eurasian shrub: contrasting Mediterranean and temperate glacial refugia.
985 Molecular Ecology 12, 3415–3426.

986 Heinz, C., 1991. Upper Pleistocene and Holocene vegetation in the South of France and Andorra.
987 Adaptations and firsts ruptures: new charcoal analysis data. Review of Paleobotany and
988 Palynology 69, 299-324.

989 Higuera, P.E., Brubaker, L.B., Anderson, P.M., Brown, T.A., Kennedy, A.T., Hu, F.S., 2008.
990 Frequent fires in ancient shrub tundra: implications of paleorecords for arctic
991 environmental change. PLoS ONE 3(3), e0001744.

992 Hooghiemstra, H., Stalling, H., Agwu, Ch.O.C., Dupont, L.M., 1992. Vegetational and climatic
993 changes at the northern fringe of the Sahara 250,000-5000 years BP: evidence from 4
994 marine pollen records located between Portugal and the Canary Islands. Review of
995 Palaeobotany and Palynology 74, 1-53.

996 Jalut, G., Esteban, A., Bonnet, L., Gauquelin, T., Fontugne, M., 2000. Holocene climatic changes
997 in the western Mediterranean, from south-east France to south-east Spain.
998 Palaeogeography, Palaeoclimatology, Palaeoecology 160, 255-290.

999 Janssen, C.R., 1994. Palynological indications for the extent of the impact of man during Roman
1000 times in the western part of the Iberian Peninsula. In: Frenzel, B. (Ed.), Evaluation of land
1001 surfaces cleared from forests in the Mediterranean Region during the time of the Roman
1002 Empire. Paleoclimate research. Gustav Fischer, Stuttgart, pp.15-22.

1003 Jiménez Sánchez, M., Ruiz-Zapata, M.B., Farias Arquer, P., Dorado-Valiño, M., Gil-García, M.J.,
1004 Valdeolmillos Rodríguez, A., 2003. Palaeoenviromental research in Cantabrian
1005 Mountains: Redes Natural Park and Comella Basin. In: Ruíz-Zapata, M.B., Dorado-
1006 Valiño, M., Valdeolmillo Rodríguez, A., Gil-García, M.J., Bardají Azcárate, T.,
1007 Bustamante Gutiérrez, I., Martínez Mendizábal, I. (Eds.), Quaternary climatic changes
1008 and environmental crises in the Mediterranean Region. Universidad de Alcalá de
1009 Henares, Ministerio de Ciencia y Tecnología, INQUA, Alcalá de Henares, pp. 229-240.

1010 Jiménez, P., López-de-Heredia, U., Collada, C., Lorenzo, Z., Gil, L., 2004. High variability of
1011 chloroplast DNA in three Mediterranean evergreen oaks indicates complex evolutionary
1012 history. Heredity 93, 510–515.

1013 Julià, R., Burjachs, F., Dasí, M.J., Mezquita, F., Miracle, M.R., Roca, J.R., Seret, G., Vicente, E.,
1014 1998. Meromixis origin and recent trophic evolution in the Spanish mountain lake La
1015 Cruz. Aquatic Sciences 60(4), 279-299.

1016 Lamb, H.F., Gasse, F., Benkaddour, A., El Hamouti, N., van der Kaars, S., Perkins, W.T., Pearce,
1017 N.J., Roberts, C.N., 1995. Relation between century-scale Holocene arid intervals in
1018 tropical and temperate zones. Nature 373, 134-137.

1019 Lauritzen, S.E., 1996. Calibration of speleothem stable isotope against historical records: a
1020 Holocene temperature curve for north Norway? Climatic change: the karst record. In:
1021 Lauritzen, S.E. (Ed.), Karst Waters Institute Special Publication nº 2. Charles Town, West
1022 Virginia, pp. 78-80.

1023 Leroy, S.A.G., Arpe, K., 2007. Glacial refugia for summer-green trees in Europe and south-west
1024 Asia as proposed by ECHAM3 time-slice atmospheric model simulations. Journal of
1025 Biogeography 34(12), 2115–2128.

1026 López de Heredia, U., Carrión, J.S., Jiménez, P., Collada, C., Gil, L., 2007. Molecular and
1027 palaeobotanical evidence for multiple glacial refugia for evergreen oaks in the Iberian
1028 Peninsula. Journal of Biogeography 34, 1505-1517.

1029 López-García, P., 1977. Análisis polínico de Verdelpino (Cuenca). In: Moure Romanillo, J.A.,
1030 Fernández-Miranda, M. (Coords.), El abrigo de Verdelpino (Cuenca). Noticias de los
1031 trabajos de 1976. Apéndice II. Trabajos de Prehistoria 34, 31-83.

1032 López-García, P., 1981. Análisis polínico del yacimiento de Los Azules (Cangas de Onís,
1033 Oviedo). Botanica Macaronesica 8/9, 243-248.

1034 López-García, P., Arnanz, A., Uzquiano, P., López-Sáez, J.A., 1997. Los elementos antrópicos
1035 en los análisis arqueobotánicos como indicadores de los usos del suelo. In: García Ruiz,
1036 J.M., López-García, P. (Eds.), Acción humana y desertificación en ambientes
1037 mediterráneos. Instituto Pirenaico de Ecología, Zaragoza, pp. 41-59.

1038 López-García, P., Arnanz, A., Uzquiano, P., Macías, R., Gil, P., 2003. Informes Técnicos: 1
1039 Paleobotánica. In: Estremera, M.S., (Ed.), Primeros agricultores y ganaderos en la
1040 Meseta Norte: el Neolítico de la Cueva de la Vaquera (Torreiglesias, Segovia). Memorias
1041 de Arqueología en Castilla y León, vol. 11. Junta de Castilla y León, Zamora, pp. 247-
1042 256.

1043 López-Merino, L., López-Sáez, J.A., López-García, P., 2006. Estudio palinológico de la turbera
1044 litoral holocena de Las Dueñas (Cudillero, Asturias, España). Revista Española de
1045 Micropaleontología 38(2-3), 299-308.

1046 López-Merino, L., 2009. Paleoambiente y antropización en Asturias durante el Holoceno. Ph.D.
1047 thesis. Universidad Autónoma de Madrid, Madrid.

1048 López-Merino, L., López-Sáez, J.A., Ruíz-Zapata, M.B., Gil-García, M.J., 2008. Reconstructing
1049 the history of beech (*Fagus sylvatica* L.) in the north-western Iberian Range (Spain):
1050 From Late-Glacial refugia to the Holocene anthropic-induced forests. Review of
1051 Palaeobotany and Palynology 152, 58-65.

1052 López-Sáez, J.A., 2002. Análisis paleopalinológico del yacimiento Dehesa de Río Fortes
1053 (Mironcillo, Ávila). Boletín del Seminario de Estudios de Arte y Arqueología 68, 42-48.

1054 López-Sáez, J.A., López-Merino, L., 2005. Precisiones metodológicas acerca de los indicios
1055 paleopalinológicos de agricultura en la Prehistoria de la Península Ibérica. Portugalia 26,
1056 53-64.

1057 López-Sáez, J.A., López-Merino, L., 2007. Coprophilous fungi as a source of information on
1058 anthropic activities during the Prehistory in the Amblés Valley (Ávila, Spain): The
1059 archaeopalynological record. Revista Española de Micropaleontología 39(1-2), 103-116.

1060 López-Sáez, J.A., van Geel, B., Farbos-Texier, S., Diot, M.F., 1998. Remarques
1061 paléoécologiques à propos de quelques palynomorphes non-polliniques provenant de
1062 sédiments quaternaires en France. Revue de Paléobiologie 17(2), 445-459.

1063 López-Sáez, J.A., van Geel, B., Martín Sánchez, M., 2000. Aplicación de los microfósiles no
1064 polínicos en Palinología Arqueológica. In: Oliveira Jorge, V. (Coord. Ed.), Contributos das
1065 Ciências e das Technologias para a Arqueologia da Península Ibérica. Actas 3º
1066 Congresso de Arqueologia Peninsular, vol. 9, Vila-Real, Portugal. Adecap, Porto, pp. 11-
1067 20.

1068 López-Sáez, J.A., López-García, P., Cruz, J.D., Canha, A.J., 2001. Palaeovegetation and human
1069 impact in the Upper Paiva region: palynology of the Late Bronze Age settlement of
1070 Canedotes (Vila Nova de Paiva, Viseu, Portugal). Journal of Iberian Archaeology 3, 47-
1071 72.

1072 López-Sáez, J.A., López-García, P., Burjachs, F., 2003. Arqueopalinología: Síntesis crítica. Polen
1073 12, 5-35.

1074 López-Sáez, J.A., López-García, P., López-Merino, L., Cerrillo Cuenca, E., González Cordero, A.,
1075 Prada, A., 2005. Prehistoric landscapes in North Extremadura between the VIth and the
1076 IVth millenia cal. BC. Journal of Iberian Archaeology 7, 23-35.

1077 López-Sáez, J.A., Monteiro-Rodrigues, S., López-Merino, L., 2006-2007. La transición Mesolítico-
1078 Neolítico desde una perspectiva paleoambiental: análisis palinológico del sitio
1079 arqueológico de Prazo (Freixo de Numão, Portugal). Portugalia 27/28, 19-34.

1080 López-Sáez, J.A., González Cordero, A., Cerrillo Cuenca, E., 2007. Paleoambiente y
1081 paleoeconomía durante el Neolítico antiguo y el Calcolítico en Extremadura: análisis
1082 arqueopalinológico del yacimiento del Cerro de la Horca (Plasenzuela, Cáceres,
1083 España). Zephyrus 60, 145-153.

1084 López-Sáez, J.A., Blanco González, A., López-Merino, L., Ruíz-Zapata, M.B., Dorado-Valiño, M.,
1085 Pérez Díaz, S., Valdeolmillos, A., Burjachs, F., 2008. Landscape and climatic changes
1086 during the end of the Late Prehistory in the Amblés Valley (Ávila, central Spain), from
1087 1200 to 400cal BC. Quaternary International 200, 90-101.

1088 Magri, D., Vendramin, G., Comps, B., Dupanloup, I., Geburek, Th., Gömöry, D., Latalowa, M.,
1089 Litt, Th., Paule, L., Roure, J.M., Tantau, I., van de Knaap, W.O., Petit, R.J., Beaulieu,
1090 J.L., 2006. A new scenario for the Quaternary history of European beech populations:
1091 Palaeobotanical evidence and genetic consequences. New Phytologist 171,199-221.

1092 Mariscal, B., 1983. Estudio de la turbera del Cueto de la Avellanosa, Polaciones (Cantabria). VI
1093 Reunión del Grupo Español de trabajo del Cuaternario. Cuaderno do Laboratorio
1094 Xeoloxico de Laxe 5, 205-226.

1095 Martínez-Atienza, F., 1999. Bibliografía (1945-1998) paleopolínica del Holoceno ibérico. Boletín
1096 de la Real Sociedad Española de Historia Natural (Sección Biológicas) 95, 5-30.

1097 Mateus, J.E., 1989. Lagoa Travessa: a Holocene pollen diagram from the south-west coast of
1098 Portugal. Revista de Biología 14, 17-94.

1099 Mayewski, P.A., Rohling, E.E., Stager, J.C., Karlén, W., Maasch, K.A., Meeker, L.D., Meyerson,
1100 E.A., Gasse, F., van Kreveld, S., Holmgren, K., Lee-Thorp, J., Rosqvist, G., Rack, F.,
1101 Staubwasser, M., Schneider, R.R., Steig, E.J., 2004. Holocene climate variability.
1102 Quaternary Research 62, 243-255.

1103 Medail, F., Diadema, K., 2009. Glacial refugia influence plant diversity patterns in the
1104 Mediterranean Basin. Journal of Biogeography 36, 1333-1345.

1105 Menéndez Amor, J., 1975. Análisis esporo-polínico de los sedimentos turbosos de los lagos Enol
1106 y Ercina. Boletín de la Real Sociedad Española de Historia Natural (sección Geología)
1107 66, 311-313.

1108 Menéndez Amor, J., Florschütz, F., 1963. Sur les éléments steppiques dans la végétation
1109 quaternaire de l'Espagne. Boletín de la Real Sociedad Española de Historia Natural
1110 (sección Geología) 61, 121-133.

1111 Misiego, J.C., Marcos, G.J., Martín, M.A., Sanz, F.J., Villanueva, L.A., 2005. Guaya (Berrocalejo
1112 de Aragona, Ávila): Reconstrucción de la vida y economía de un poblado en los albores
1113 de la Edad del Hierro. In: Blanco, E., Cancelo, C., Esparza, A. (Eds.), Bronze Final y
1114 Edad del Hierro en la Península Ibérica. Ediciones Universidad de Salamanca, Colección
1115 Aquilafuente 6, Salamanca, pp. 207-228.

1116 Montserrat, J., Vilaplana, J.M., 1987. The paleoclimatic records of the Upper Pleistocene and
1117 Holocene in the Llauset Valley (Central Southern Pyrenees). Pirineos 129, 107-113.

1118 Montserrat, J., 1992. Evolución glaciar y postglaciar del clima y la vegetación en la vertiene sur
1119 del Pirineo: Estudio palinológico. Monografías del Instituto Pirenaico de Ecología 6,
1120 Instituto Pirenaico de Ecología, CSIC, Zaragoza.

1121 Moreno, A., López-Merino, L., Leira, M., Marco Barba, J., González-Sampériz, P., Valero-Garcés,
1122 B.L., López-Sáez, J.A., Santos, L., Mata, P., Ito, E., 2009. Revealing Holocene
1123 environmental history from the multiproxy record of a mountain lake (Lago Enol, N Iberian
1124 Peninsula). Journal of Paleolimnology. Doi: 10.1007/s10933-009-9387-7.

1125 Muñoz-Sobrino, C., Ramil-Rego, P., Delibes de Castro, G., Rojo Guerra, M., 1996. Datos
1126 paleobotánicos sobre la turbera de la Piedra (Páramo de Tozo, Burgos). In: Ramil-Rego,
1127 P., Fernández Rodríguez, C., Rodríguez Guitián, M. (Eds.), Biogeografía pleistocena-
1128 holocena de la Península Ibérica. Xunta de Galicia. Santiago de Compostela, pp. 149-
1129 162.

1130 Muñoz-Sobrino, C., Ramil-Rego, P., Rodríguez Guitián, M., 1997. Upland vegetation in the north-
1131 west Iberian Peninsula after the last glaciation: forest history and deforestation dynamics.
1132 Vegetation History and Archaeobotany 6, 215-233.

1133 Muñoz-Sobrino, C., Rodríguez Guitián, M.A., Ramil-Rego, P., 1995. Cambios en la cubierta
1134 vegetal durante el Pleistoceno y el Holoceno en la Sierra de Ancares (NW Ibérico). In:
1135 Aleixandre Campos, T., Pérez González, A. (Eds.), Reconstrucción de paleoambientes y
1136 cambios climáticos durante el Cuaternario. Centro de Ciencias Medioambientales,
1137 C.S.I.C., Monografías 3, Madrid, pp. 309-318.

1138 Muñoz-Sobrino, C., Ramil-Rego, P., Rodríguez Guitián, M.A., 2001. Vegetation in the mountains
1139 of northwest Iberia during the last glacial-interglacial transition. Vegetation History and
1140 Archaeobotany 10, 7-21.

1141 Muñoz-Sobrino, C., Ramil-Rego, P., Gómez-Orellana, L., 2004. Vegetation of the Lago de
1142 Sanabria area (NW Iberia) since the end of the Pleistocene: a palaeoecological
1143 reconstruction on the basis of two new pollen sequences. Vegetation History and
1144 Archaeobotany 13, 1-22.

1145 Muñoz-Sobrino, C., Ramil-Rego, P., Gómez-Orellana, L., Díaz Varela, R.A., 2005. Palynological
1146 data on major Holocene climatic events in NW Iberia. Boreas 34, 381-400.

1147 Muñoz-Sobrino, C., Ramil-Rego, P., Gomez Orellana, L., 2007. Late Würm and early Holocene in
1148 the mountains of northwest Iberia: biostratigraphy, chronology and tree colonization.
1149 Vegetation History and Archaeobotany 16, 223-240.

1150 Muñoz-Sobrino, C., Ramil-Rego, P., Gómez-Orellana, L., Ferreiro da Costa, J., Díaz Varela, R.A.,
1151 2009. Climatic and human effects on the post-glacial dynamics of *Fagus sylvatica* L. in
1152 NW Iberia. Plant Ecology 203, 317-340.

1153 Naughton, F., Sánchez Goñi, M.F., Desprat, S., Turon, J.L., Duprat, J., Malaize, B., Joli, C.,
1154 Cortijo, E., Drago, T., Freitas, M.C., 2007. Present-day and past (last 25000 years)
1155 marine pollen signal off western Iberia. Marine Micropaleontology 62, 91-114.

1156 Nocete, F., Alex, E., Nieto, J.M., Sáez, R., Bayona, M.R., 2005. An archaeological approach to
1157 regional environmental pollution in the south-western Iberian Peninsula related to Third
1158 millennium BC mining and metallurgy. Journal of Archaeological Science 32, 1566-1576.

1159 Ojeda, F., Brun, F.G., Vergara, J.J., 2005. Fire, rain and the selection of seeder and resprouter
1160 life-histories in fire-recruiting, woody plants. New Phytologist 168, 155-165.

1161 Pantaleón-Cano, J., 1997. Estudi palinològic de sediments litorals de la provincia d'Almería.
1162 Transformacions del paitsatge vegetal dins un territori semiàarid. Ph.D. thesis,
1163 Universitat Autonoma de Barcelona.

1164 Pantaleón-Cano, J., Pérez-Obiol, R., Yll, E.I., Roure, J.M., 1996. Significado de *Pseudoschizaea*
1165 en secuencias sedimentarias de la vertiente mediterránea de la Península Ibérica e Islas
1166 Baleares. In: Ruíz-Zapata, M.B. (Ed.), Estudios Palinológicos. Universidad de Alcalá de
1167 Henares. Alcalá de Henares, pp. 101-105.

1168 Pantaleón-Cano, J., Yll, E.I., Pérez-Obiol, R., Roure, J.M., 2003. Palynological evidence for
1169 vegetational history in semi-arid areas of the western Mediterranean (Almería, Spain).
1170 The Holocene 13, 109-119.

1171 Parra, I., 1993. Desplaçaments latitudinals de la vegetació al litoral Mediterrani durant els darrers
1172 8.500 anys. Un enfocament pol·línic i climatic. Revista Catalana de Geografía 8, 37-44.

1173 Parra, I., 1994. Quantification des précipitations à partir des spectres polliniques actuels et
1174 fossiles: du Tardiglaciaire à l´Holocène Supérieur de la côte méditerranéene espagnole.
1175 Ph.D. thesis, Université de Montpellier, Francia.

1176 Pausas, J.G., Keeley, J.E., 2009. A burning story: the role of fire in the history of life. BioScience
1177 59, 593-601.

1178 Peinado Lorca, M., Rivas-Martínez, S., 1987. La vegetación de España. Servicio de
1179 publicaciones de la Universidad de Alcalá de Henares, España.

1180 Pèlachs, A., Esteban, A., Soriano, J.M., 2001. Evolución glaciar y dinámica de la vegetación en el
1181 Pirineo central catalán: el complejo glacio-lacustre de Burg (Farrera, Pallars Sobirà,
1182 Lleida). Treballs de la Societat Catalana de Geografía 52, 293-310.

1183 Peña-Chocarro, L., Zapata Peña, L., Iriarte, M.J., González Morales, J., Straus, L.G., 2005. The
1184 oldest agriculture in northern Atlantic Spain: new evidence from El Mirón Cave (Ramales
1185 de la Victoria, Cantabria). Journal of Archaeological Science 32, 579-587.

1186 Peñalba, M.C., 1994. The history of the Holocene vegetation in northern Spain from pollen
1187 analysis. Journal of Ecology 82, 815-832.

1188 Peñalba, M.C., Arnold, M., Guiot, J., Duplessy, J.C., de Beaulieu, J.L., 1997. Termination of the
1189 last glaciation in the Iberian Peninsula inferred from the pollen sequence of Quintanar de
1190 la Sierra. Quaternary Research 48, 205-214.

1191 Pérez-Obiol, R., Julià, R., 1994. Climatic change on the Iberian Peninsula recorded in a 30,000-yr
1192 pollen record from Lake Banyoles. Quaternary Research 41, 91-98.

1193 Piqué, R., 2005. Paisaje y gestión de recursos forestales entre el VI y IV milenio cal. BC en el
1194 nordeste de la Península Ibérica. In: Ontañón Peredo, R., García-Moncó Piñeiro, C.,
1195 Arias Cabal, P. (Coords.) Actas del III Congreso del Neolítico en la Península Ibérica.
1196 Santander, pp. 45-52.

1197 Planchais, N.,Parra, I., 1984. Analyses polliniques de sédiments lagunaires et cotiers en
1198 Languedoc, en Roussillon et Dans la province de Castellon (Espagne); bioclimatologie.
1199 Bulletin Societé Botanique Française 131(2-3-4), 97-105.

1200 Pons, A., Reille, M., 1988. The Holocene and Upper Pleistocene pollen record from Padul
1201 (Granada, Spain): a new study. Palaeogeography, Palaeoclimatology, Palaeoecology 66,
1202 243-263.

1203 Postigo, J.M., Gómez Manzaneque, F., Morla, C., 2008. Survival and long-term maintenance of
1204 tertiary trees in the Iberian Peninsula during the Pleistocene. First record of *Aesculus* L.
1205 (Hippocastanaceae) in Spain. Vegetation History and Archaeobotany 17, 351-364.

1206 Provan, J., Bennett, K.D., 2008. Phylogeographic insights into cryptic glacial refugia. Trends in
1207 Ecology and Evolution 23(10), 564-571.

1208 Ramil-Rego, P., 1993. Evolución climática e historia de la vegetación durante el Pleistoceno
1209 Superior y el Holoceno en las regiones montañosas del Noroeste Ibérico. In: Pérez
1210 Alberti, A., Guitián Rivera, L., Ramil-Rego, P. (Eds.), La evolución del paisaje en las
1211 montañas del entorno de los Caminos Jacobeos. Xunta de Galicia, A Coruña, pp. 25-60.

1212 Ramil-Rego, P., Gómez-Orellana, L., 1996. Dinámica climática y biogeográfica del área litoral-
1213 sublitoral de Galicia durante el Pleistoceno Superior-Holoceno. In: Ramil-Rego, P. (Ed.),
1214 Biogeografía pleistocena-holocena de la Península Ibérica. Xunta de Galicia, Santiago
1215 de Compostela, pp. 43-71.

1216 Ramil-Rego, P., Aira Rodríguez, M.J., Alonso Mattias, F., 1993a. Caracterización climática y
1217 vegetacional de la Serra de Geres (Portugal) durante el Tardiglaciar y el Holoceno:
1218 análisis polínico de a Lagoa do Marinho. Actas 3ª Reunión del Cuaternario Ibérico, pp.
1219 85-92.

1220 Ramil-Rego, P., Taboada Castro, M.T., Aira Rodríguez, M.J., 1993b. Estudio palinológico y
1221 factores de formación de la turbera de Gañidoira (Lugo, España). In: Fumanal, M.P.,
1222 Bernabeu, J. (Eds.), Estudios sobre Cuaternario, medios sedimentarios, cambios
1223 ambientales, hábitat humano. Universitat de València, València, pp. 191-197.

1224 Ramil-Rego, P., Múñoz Sobrino, C., Rodríguez-Guitián, M., Gómez-Orellana, L., 1998.
1225 Differences in the vegetation of the North Iberian Peninsula during the last 16,000 years.
1226 Plant Ecology 138, 41-62.

1227 Ramil-Rego, P., Rodríguez Guitián, M.A., Muñoz-Sobrino, C., Gomez Orellana, L., 2000. Some
1228 considerations about the postglacial history and recent distribution of *Fagus sylvatica* in
1229 the NW Iberian Peninsula. Folia Geobotanica 35, 241-271.

1230 Reed, J.M., Stevenson, A.C., Juggins, S., 2001. A multi-proxy record of Holocene climatic change
1231 in southwestern Spain: the Laguna de Medina, Cádiz. The Holocene 11, 707-719.

1232 Rey Benayas, J.M., Scheiner, S.M., 2002. Plant diversity, biogeography and environment in
1233 Iberia: Patterns and possible causal factors. Journal of Vegetation Sciences 13, 245-258.

1234 Rochette Cordeiro, A.M., Denèfle, M., Vergne, V., 1991. Importance du facteur anthropique dans
1235 deux tourbières des montagnes occidentales du centre-nord du Portugal. Cadernos de
1236 Geografia 10, 273-282.

1237 Rodó, X., Giralt, S., Burjachs, F., Comín, F.A., Tenorio, R.F., Julià, R., 2002. High-resolution
1238 saline lake sediments as enhanced tools for relating proxy paleolake records to recent
1239 climatic data series. Sedimentary Geology 148, 203-220.

1240 Rodríguez-Ariza, M.O., 1992. Human-plant relationships during the Copper and Bronze Age in
1241 the Baza and Guadix basins (Granada, Spain). Bulletin de la Société Botanique de la
1242 France 139, Actualités botaniques (2-3-4), 451-464.

1243 Rodríguez-Ariza, M.O., 1995. Análisis antracológicos de yacimientos neolíticos de Andalucía.
1244 Rubricatum 1, 73-83.

1245 Rodríguez-Ariza, M.O., 2000. El paisaje vegetal de la Depresión de Vera durante la Prehistoria
1246 reciente. Una aproximación desde la antracología. Trabajos de Prehistoria 57, 145-156.

1247 Rodríguez-Ariza, M.O., Vernet, J.L., 1991. Etude paléoécologique du gisement chalcolithique de
1248 Los Millares (Santa Fé de Mondújar, Almería). In: Waldren, W.H., Ensenyat, J.A.,
1249 Kennard, R.C. (Eds.), Recent developments in western Mediterranean prehistory:
1250 archaeological techniques, technology and theory. BAR International Series 573, Oxford,
1251 pp. 1-16.

1252 Ros-Mora, M.T., 1985. Contribució antracoanalítica a l'estudi de l'entorn vegetal de l'home del
1253 Paleolític Superior a l'edat de ferro a Catalunya. Ph.D. thesis. Universitat Autònoma de
1254 Barcelona. Barcelona.

1255 Ros Sala, M.M., 2008. La Punta de Los Gavilanes: un asentamiento en el tiempo en el litoral de
1256 la Bahía de Mazarrón (Murcia). Memoria Arqueológica de las campañas de trabajo 1998-
1257 2004. Dirección General de Bienes Culturales y Museos de la CARM, Murcia.

1258 Roucoux, K.H., de Abreu, L., Shackleton, N.J., Tzedakis, P.C., 2005. The response of NW Iberian
1259 vegetation to North Atlantic climate oscillations during the last 65 kyr. Quaternary Science
1260 Reviews 24, 1637-1653.

1261 Rubiales, J.M., García-Amorena, I., Génova, M., Gómez Manzaneque, F., Morla, C., 2007. The
1262 Holocene history of highland pine forests in a submediterranean mountain: the case of
1263 Gredos mountain range (Iberian Central range, Spain). Quaternary Science Reviews 26,
1264 1759-1770.

1265 Rubiales, J.M., García-Amorena, I., García Álvarez, S., Morla, C., 2009. Anthracological evidence
1266 suggests naturalness of *Pinus pinaster* in inland southwestern Iberia. Plant Ecology 200,
1267 155-160.

1268 Ruíz-Zapata, B., Andrade, A., Gil-García, M.J., Dorado Valiño, M., Atienza Ballano, M., 1996.
1269 Evolución de la vegetación en los últimos 6.000 años en los sectores central y oriental
1270 del Sistema Central Español. Revista Española de Paleontología Número Extraordinario,
1271 288-298.

1272 Ruíz-Zapata, M.B., Farias, P., Jiménez Sánchez, M., Gil-García, M.J., Dorado-Valiño, M.,
1273 Valdeolmillos Rodríguez, A., 2001. Secuencia polínica de un depósito de la depresión de
1274 Comeya (Picos de Europa, Asturias): implicaciones paleoclimáticas. In: Moreno Grau, S.,
1275 Rendueles, B., Moreno Angosto, J.M. (Eds.), XIII Simposio de la Asociación de
1276 Palinólogos de Lengua Española (A.P.L.E.). Universidad Politécnica de Cartagena,
1277 Cartagena, pp. 379-389.

1278 Ruíz-Zapata, M.B., Gil, M.J., Dorado, M., Valdeolmillos, A., Vegas, J., Pérez González, A., 2002.
1279 Clima y vegetación durante el Tardiglaciar y el Holoceno en la Sierra de Neila (Sistema
1280 Ibérico Noroccidental). Cuaternario y Geomorfología 16(1-4), 9-20.

1281 Ruíz-Zapata, M.B., López-Sáez, J.A., Vegas, J., López-García, M.J., Pérez González, A., Gil-
1282 García, M.J., Dorado, M., Valdeolmillos, A., 2003a. Environmental changes during the
1283 Late Glacial-Holocene transition in Sierra de Neila (Laguna Grande lacustrine record,
1284 Spain). In: Ruíz-Zapata, M.B., Dorado, M., Valdeolmillos, A., Gil, M.J., Bardají, T.,
1285 Bustamante, I., Martínez, I. (Eds.), Quaternary climatic changes and environmental crises
1286 in the Mediterranean region. Universidad de Alcalá de Henares, Ministerio de Ciencia y
1287 Tecnología, INQUA, Alcalá de Henares, pp. 139-147.

1288 Ruíz-Zapata, M.B., Ortega Martínez, A.I., Dorado, M., Valdeolmillos, A., Gil-García, M.J.,
1289 Arsuaga, J.L., Carretero Díaz, J.M., Martínez Mendizábal, I., Pérez González, A., 2003b.
1290 Vegetational history during Bronze and Iron ages in Portalón cave (Sierra de Atapuerca,
1291 Burgos, Spain). In: Ruiz, M.B., Dorado, M., Valdeolmillos, A., Gil, M.J., Bardají, T., de
1292 Bustamante, I., Martínez-Mendizábal, I. (Eds.), Quaternary Climatic Changes and
1293 Environmental crises in the Mediterranean Region. Universidad de Alcalá de Henares,
1294 Ministerio de Ciencia y Tecnología, INQUA, Alcalá de Henares, pp. 99-106.

1295 Ruíz-Zapata, M.B., Gómez González, C., López-Sáez, J.A., Gil-García, M.J., Santiesteban, J.I.,
1296 Mediavilla, R., Dorado-Valiño, M., Valdeolmillos Rodríguez, A., 2006. Detección de la
1297 actividad antrópica durante el Holoceno reciente, a través de la asociación de
1298 palinomorfos polínicos y no polínicos en dos depósitos higroturbosos (El Berrueco y
1299 Rascafría) en la Sierra de Guadarrama, Madrid. Revista Española de Micropaleontología
1300 38(2-3), 355-366.

1301 Ruíz-Zapata, M.B., Gómez González, C., Gil-García, M.J., Pérez-González, A., Baquedano, E.,
1302 Arsuaga, J.L., López-Sáez, J.A., Bauz, S., Márquez, B., 2007. Clima y vegetación
1303 durante el Holoceno reciente en El Calvero de la Higuera (Pinilla del Valle, Madrid):
1304 Nuevos datos polínicos. Revista Española de Micropaleontología 39(3), 215-226.

1305 Sánchez-Goñi, M.F., Hannon, G.E., 1999. High-altitude vegetational pattern on the Iberian
1306 Mountain Chain (North-Central Spain) during the Holocene. The Holocene 9, 39-57.

1307 Sánchez-Goñi, M.F., Cacho, I., Turon, J.L., Guiot, J., Sierro, F.J., Peypouquet, J.P., Grimalt, J.O.,
1308 Shackleton, N.J., 2002. Synchroneity between marine and terrestrial responses to
1309 millennial scale climatic variability during the last glacial period in the Mediterranean
1310 region. Climate Dynamics 19, 95-105.

1311 Santos, L., Sánchez Goñi, M.F., Freitas, M.C., Andrade, C., 2002. Cambios climáticos y
1312 vegetacionales en la zona costera de Melides (SO Portugal) durante el Holoceno. In:
1313 Valle, M., Rivas Carballo, M.R. (Eds.), Libro de Resúmenes del XIV Simposio de
1314 Palinología de la Asociación de Palinólogos de Lengua Española (APLE). Universidad de
1315 Salamanca. Salamanca, pp. 143-144.

1316 Santos, L., Sánchez Goñi, M.F., Freitas, M.C., Andrade, C., 2003. Climatic and environmental
1317 changes in the Santo André coastal area (SW Portugal) during the last 15000 years. In:
1318 Ruíz-Zapata, M.B., Dorado, M., Valdeolmillos, A., Gil, M.J., Bardají, T., Bustamante, I.,
1319 Martínez, I. (Eds.), Quaternary climatic changes and environmental crises in the
1320 Mediterranean region. Universidad de Alcalá de Henares - Ministerio de Ciencia y
1321 Tecnología - INQUA. Alcalá de Henares, pp. 175-179.

1322 Santos, L., Vidal Romaní, J.R., Jalut, G., 2000. History of vegetation during the Holocene in the
1323 Courel and Queixa Sierras, Galicia, northwest Iberian Peninsula. Journal of Quaternary
1324 Science 15(6), 621-632.

1325 Stevenson, A.C., 1985. Studies in the vegetational history of SW Spain. II. Palynological
1326 investigations at Laguna de las Madres, SW Spain. Journal of Biogeography 12, 293-
1327 314.

1328 Stevenson, A.C., 2000. The Holocene forest history of the Montes Universales, Teruel, Spain.
1329 The Holocene 10, 603-610.

1330 Stevenson, A.C., Moore, P.D., 1988. Studies in the vegetational history of S.W. Spain. IV.
1331 Palynological investigations at El Acebrón, Huelva. Journal of Biogeography 15, 339-361.

1332 Stevenson, A.C., Harrison, R.J., 1992. Ancient forests in Spain: a model for land-use and dry
1333 forest management in south-west Spain from 4000 BC to 1900 AD. Proceedings of the
1334 Prehistoric Society 58, 227-247.

1335 Stewart, J.R., Dalén, L., 2008. Is the glacial refugium concept relevant for northern species? A
1336 comment on Pruett and Winker 2005. Climatic Change 86, 19-22.

1337 Tinner, W., Hu, F.S., Beer, R., Kaltenrieder, P., Scheurer, B., Krähenbühl, U., 2006. Postglacial
1338 vegetational and fire history: pollen, plant macrofossil and charcoal records from two
1339 Alaskan lakes. Vegetation History and Archaeobotany 15, 279-293.

1340 Törnqvist, T.E., Janssen, C.R., Pérez Alberti, A., 1989. Degradación antropogénica de la
1341 vegetación en el noroeste de Galicia durante los últimos 2500 años. Cuadernos de
1342 Estudios Gallegos 38, 175-198.

1343 Uzquiano, P., 1990. La transition tardiglaciare/postglaciare dans la Cordillère Cantabrique
1344 (Asturias et Cantabria), d´après l´analyse anthracologique. Monografías del Instituto
1345 Pirenaico de Ecología 5, 469-476.

1346 Uzquiano, P., 1992a. Recherces anthracologiques dans le secteur Pyreneo-Cantabrique (Pays
1347 Basque, Cantabria et Asturias): Environnements et relations Homme-Milieu au
1348 Pléistocene Supérier et debut de l'Holocene. Ph.D. thesis, Université Montpellier,
1349 Francia.

1350 Uzquiano, P., 1992b. The Late Glacial/Postglacial transition in the Cantabrian Cordillera (Asturias
1351 and Cantabria, Spain) based on charcoal analysis. Palaios 7, 540-547.

1352 Uzquiano, P., 1995. L´evolution de la vegetation a l´holocene initial dans le nord de l´Espagne a
1353 partir de l´etude anthrocologique de trois sites archeologiques. Quaternaire 6(2), 77-83.

1354 Valdeolmillos, A., 2004. Registro paleoclimático y paleoambiental de los últimos 350,000 años en
1355 el Parque Nacional de Las Tablas de Daimiel (Ciudad Real). Ph.D. thesis, Universidad
1356 de Alcalá de Henares, Madrid.

1357 Valdeón, J., Salrach, J.M., Zabalo, J., 1994. Historia de España IV: feudalismo y consolidación
1358 de los pueblos hispánicos (siglos XI-XV). Labor, Barcelona. 475 pp.

1359 Valero-Garcés, B.L., Moreno, A., Navas, A., Mata, P., Machín, J., Delgado-Huertas, A.,
1360 González-Sampériz, P., Schwalb, A., Morellón, M., Hai Cheng, Edwards, R.L., 2008. The
1361 Taravilla lake and tufa deposits (Central Iberian Range, Spain) as palaeohydrological and
1362 palaeoclimatic indicators. Palaeogeography, Palaeoclimatology, Palaeoecology 259(2-3),
1363 136-156.

1364 Valero-Garcés, B.L., Delgado-Huertas, A., Navas, A., Machín, J., González-Sampériz, P., Kelts,
1365 K., 2000a. Quaternary paleohydrological evolution of a playa lake, Salada Mediana,
1366 central Ebro Basin, Spain. Sedimentology 47, 1135-1156.

1367 Valero-Garcés, B.L., González-Sampériz, P., Delgado-Huertas, A., Navas, A., Machín, J., Kelts,
1368 K., 2000b. Late Glacial and Late Holocene environmental vegetational change in Salada
1369 Mediana, central Ebro Basin, Spain. Quaternary International 73, 29-46.

1370 Valero-Garcés, B.L., González-Sampériz, P., Navas, A., Machín, J., Delgado-Huertas, A., Peña-
1371 Monné, J.L., Sancho, C., Stevenson, A., Davis, B., 2004. Palaeohydrological fluctuations
1372 and steppe vegetation at the last Glacial Maximum in the Central Ebro valley (NE Spain).
1373 Quaternary International 122, 43-55.

1374 van den Brink, L.M., Janssen, C.R., 1985. The effect of human activities during cultural phases
1375 on the development of montane vegetation in the Serra da Estrela, Portugal. Review of
1376 Palaeobotany and Palynology 44, 193-215.

1377 van der Knaap, W.O., van Leeuwen, J.F.N., 1994. Holocene vegetation, human impact, and
1378 climatic change in Serra da Estrela, Portugal. Dissertationes Botanicae 234, 497-535.

1379 van der Knaap, W.O., van Leeuwen, J.F.N., 1995. Holocene vegetation succession and
1380 degradation as responses to climatic change and human activity in the Serra de Estrela,
1381 Portugal. Review of Palaeobotany and Palynology 89, 153-211.

1382 van der Knaap, W.O., van Leeuwen, J.F.N., 1997. Late Glacial and early Holocene vegetation
1383 sucession, altitudinal vegetation zonation, and climatic change in the Serra da Estrela,
1384 Portugal. Review of Palaeobotany and Palynology 97(3-4), 239-285.

1385 van der Schriek, T., Passmore, D., Stevenson, A.C., Rolão, J., 2007. The palaeogeography of
1386 Mesolithic settlement-subsistence and shell midden formation in the Muge valley, Lower
1387 Tagus Basin, Portugal. The Holocene 17, 369-385.

1388 van Geel, B., Bohncke, S.J.P., Dee, H., 1981. A palaeoecological study of an Upper Late Glacial
1389 and Holocene sequence from De Borchert, The Netherlands. Review of Palaeobotany
1390 and Palynology 31, 367-448.

1391 van Geel, B., Klink, A.G., Pals, J.P., Wiegers, J., 1986. An upper Eemian lake deposit from
1392 Twente, eastern Netherlands. Review of Palaeobotany and Palynology 46, 31-61.

1393 van Geel, B., Coope, G.R., van der Hammen, T., 1989. Palaeoecology and stratigraphy of the
1394 Lateglacial type section at Usselo (The Netherlands). Review of Palaeobotany and
1395 Palynology 60, 25-129.

1396 van Leeuwaarden, W., Janssen, C.R., 1985. A preliminary palynological study of peat deposits
1397 near an oppidum in the lower Tagus valley, Portugal. Actas da I Reunião do Quaternario
1398 Ibérico 2. GETC-GTPEQ, Lisboa, pp. 225-236.

1399 Vannière, B., Colombaroli, D., Chapron, E., Leroux, A., Tinner, W., Magny, M., 2008. Climate
1400 versus human-driven fire regimes in Mediterranean landscapes: the Holocene record of
1401 Lago dell'Accesa Tuscany, Italy. Quaternary Science Reviews 27, 1181-1196.

1402 Vernet, J.L., Badal Garcia, E., Grau Almero, E., 1983. La végétation néolithique du sud-est de
1403 l'Espagne (Valencia, Alicante) d'après l'analyse anthracologique. C.R. Academy of
1404 Sciences Paris 296, 669-672.

1405 Willis, K.J., van Andel, T.H., 2004. Trees or no trees? The environments of central and eastern
1406 Europe during the Last Glaciation. Quaternary Science Reviews 23, 2369-2387.

1407 Yáñez, C., Burjachs, F., Juan-Tresserras, J., Mestres, J.S., 2003. La fossa de Prats (Andorra), un
1408 jaciment del bronze mitjà al Pirineu. Revista d'Arqueologia de Ponent, 11/12, 123-150.

1409 Yll, E.I., 1995. Análisis polínico de los yacimientos de la Edad del Hierro de Soto de Medinilla, La
1410 Era Alta y La Mota (Valladolid). In: Delibes de Castro, G., Escudero Navarro, Z., Romero
1411 Carnicero, F., Morales Muñiz, A. (Eds.), Arqueología y Medio Ambiente. El primer milenio
1412 AC. en el Duero Medio. Junta de Castilla y León. Valladolid, pp. 357-370.

1413 Yll, E.I., Pérez-Obiol, R., Pantaleón-Cano, J., Roure, J.M., 1997. Palynological evidence for
1414 climatic change and human activity during the Holocene on Minorca (Balearic Islands).
1415 Quaternary Research 48, 339-347.

Yll, E.I., Carrión, J.S., Pantaleón, J., Dupré, M., La Roca, N., Roure, J.M., Pérez Obiol, R., 2003. Palinología del Cuaternario reciente en la Laguna de Villena (Alicante). Anales de Biología 25, 65-72.

Yll, E.I., Burjachs, F., Expósito, I., 2009. Descobrint els paisatges del passat. In: Marí, M. (Coord.), Vila i Ses Feixes. Els camins de l'aigua. GEN-GOB Eivissa. Eivissa, 19-40.

Zapata, L., 2002. Charcoal análisis from Basque archaeological sites: new data to understand the presence of Quercus ilex in a damp environment. In: Thiébault, S. (Ed.), Charcoal analysis. Methodological approaches, Palaeoecological results and wood uses. BAR International Series 1063. Oxford, pp. 121-126.

Zapata, L., Peña-Chocarro, L., Pérez, G., Stika, H.P., 2004. Early Neolithic agriculture in the Iberian Peninsula. Journal of World Archaeology 18(4), 285-326.

Figure Legends

Figure 1. Expected and unexpected vegetation sequences in response to lateglacial and early Holocene temperature increase (see Section: "Iberian vegetation coping with the Lateglacial-Early Holocene climatic change"). Unexpected records lie in the Mediterranean Region, from thermo and coastal areas, to high and mid-elevation mountain belts, and continental highplains as well. The areas with highest incidence of the Atlantic fronts are sensitive to climatic changes during this period. Site details in Table 1.

Figure 2. Examples of expected patterns of vegetation dynamics in the Iberian Peninsula during the Lateglacial and early Holocene. These include an increase in *Quercus* since the Lateglacial, with the earliest occurrences in southernmost and coastal regions (e.g. Padul, Guadiana Estuary), and deciduous trees (e.g. *Corylus, Fraxinus, Alnus, Fagus*) and woody scrub (e.g. *Phillyrea, Pistacia,* Ericaceae) expansion through the Holocene. Vegetation sequences in continental areas below the treeline are expected to include significant contribution of *Pinus* to the dominant oaklands, like in Sanabria. The Younger Dryas is characterized by the expansion of xerophytes.

Figure 3. Principal vegetation changes in NW Iberia during the Lateglacial and early Holocene. Note the progressive expansion of *Quercus* and other mesothermophilous trees at the expense of steppes and pine forests. This situation can be extrapolated to most of the Eurosiberian Region of Spain, although pines remained important in high-elevation areas and others of Mediterranean influence or extreme continentality. Redrawn from Muñoz-Sobrino et al. (2007).

Figure 4. Holocene vegetational developments in a montane region of the Atlantic Iberia, as shown by the synthetic pollen diagram of Charco da Candieira, central Portugal. *Quercus* prevails over *Pinus* in the forest component. The sequence includes indicators (e.g. *Cerealia, Plantago, Castanea,* among others) of anthropogenic disturbance ever since the Middle Holocene. Human activities are therefore associated with progressive opening of the landscape and increase of Cistaceae-Ericaceae scrub. Redrawn from van der Knaap and van Leeuwen (1997).

Figure 5. Main patterns of forest trees as differentiated from charcoal remains for the Mediterranean Region in the Iberian Peninsula. *Quercus* invasion of pine forests starts in the most thermic positions progressing in altitude across the early Holocene. *Pinus nigra* and *P. sylvestris* forests are inherited from glacial pine woodlands. *P. halepensis* and *Olea europaea* develop with the matorralization of ecosystems in the Mediterranean region. Human impacts are noticed from the Neolithic onwards.

Figure 6. Navarrés pollen diagram of selected types for the lateglacial and early Holocene. Full-glacial pine forests resist competition by oaks despite the lateglacial and postglacial climate changes. Mid-Holocene invasion by oaks is coherent with threshold response of local forests to increased fire virulence and correlates archaeological evidence of the first Neolithic settlements in the vicinity of the study site. Redrawn from Carrión and van Geel (1999).

Figure 7. Synthetic pollen diagram of a small group of ecologically relevant types from the Espinosa de Cerrato sequence in Palencia. Pine forests show a millennial-scale resilience and prevail as main vegetation type at about 800-900 m a.s.l. in north-central Spain. Redrawn from Franco-Múgica et al. (2001).

Figure 8. Starting times of anthropogenic disturbance according to palynological indicators in the Iberian Peninsula and Balearic Islands. The data do not suggest a clear relationship between the timing of the first cultural landscapes and the bioclimatic belts. Most of the "delayed" (Iron Age to present) sites occur in high-elevation areas, while from the coasts to the mountains there are sites with Neolithic impact of man on the vegetation landscapes, probably because of the early agricultural activities and antiquity of pastoral activities. Anthropogenic palynological indicators include not only pollen types indicative of agriculture and ruderalization (*Cerealia, Polygonum aviculare, Rumex, Vitis*, etc) or arboriculture (*Juglans, Castanea, Fraxinus, Eucalyptus*), but also spores (Sordariaceae, *Riccia*, Glomaceae) and non-pollen microfossils (*Pseudoschizaea*, Acari Oribatidae, etc). See section of "Palaeoecological indicators" for further detail. Site details in Table 1.

Figure 9. Frequencies of site type per bioclimatic belts following altitudinal gradients in the Eurosiberian and Mediterranean regions. Values for every site type per bioclimatic belt have been weighted by the total number of sites at a particular altitude.

Figure 10. Synthetic pollen diagram of Algendar (Minorca, Balearic Islands). A particular combination of taxa (*Pinus, Juniperus, Corylus*, and *Buxus*) dominate the mid-holocene

1496 assemblages, while evergreen *Quercus* rises in the phase of more intense human activities,
1497 accompanied by *Olea, Plantago*, and *Vitis*. Redrawn from Yll et al. (1997).
1498
1499 **Figure 11.** Oak-dominated landscapes may have been selected by humans, probably linked to
1500 the dehesa economy, which has been dated from Bronze Age times in southwestern Spain. This
1501 is illustrated in several pollen records such as El Acebrón, Doñana, where *Quercus* replaces the
1502 former pine woodlands while indicators of agriculture and ruderalization (*Vitis, Echium, Plantago,*
1503 *Rumex, Galium*) are present from c. 4510 cal. BP. Redrawn from Stevenson and Harrison (1992).
1504
1505 **Figure 12.** Vegetational developments in the Sierra de Baza (Carrión et al. 2007) and Sierra de
1506 Gádor (Carrión et al. 2003) of southern Spain, and correlation with patterns of human settlement.
1507 In both records, increased fire frequency (c. 4200-4100 cal. yr BP) and a change from mixed
1508 forests to sclerophyllous forest-scrub (c. 3940-3800 cal. yr BP) precedes the collapse of the
1509 Argaric Bronze culture at c. 3600 cal. yr BP. A climate trend towards greater aridity is observed
1510 ever since c. 5500 cal. yr BP. Ages in black boxes represent the dates of main changes in both
1511 sequences.
1512
1513 **Figure 13.** Temporal relationships between vegetation zones, and hypotheses for the main
1514 processes and controls of vegetational developments in the Siles sequence, Segura Mountains of
1515 southern Spain. Climatically-influenced changes occur as rapid, gradual or threshold responses
1516 to competitive interactions, aridity crises, increased water availability, grazing pressure, and fire
1517 disturbance. Lags in vegetational developments occur at the centennial scale. Biotically-induced
1518 changes of vegetation are mainly shown at the intrazonal variation level. Modified from Carrión
1519 (2002).
1520

Figure 1

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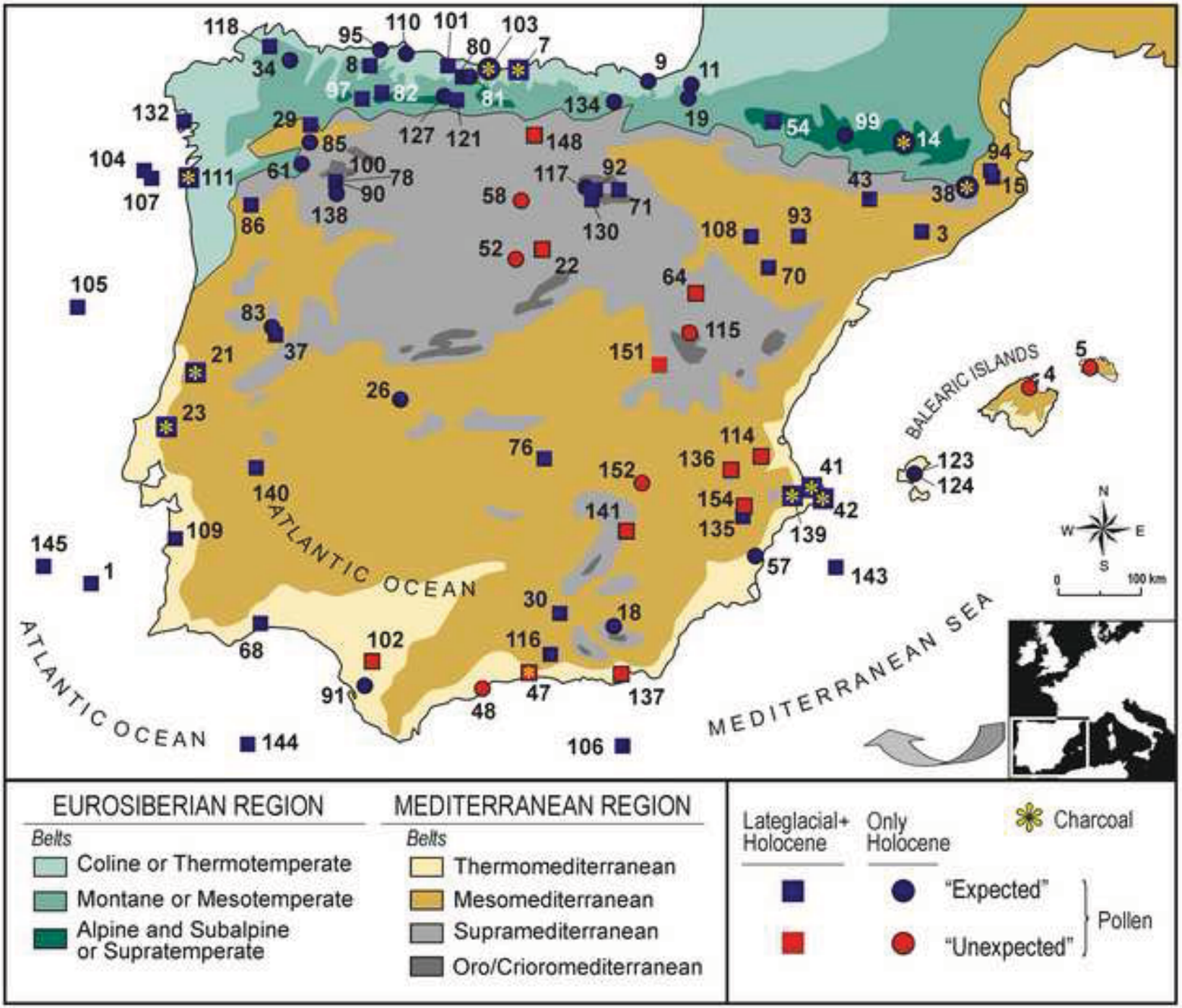

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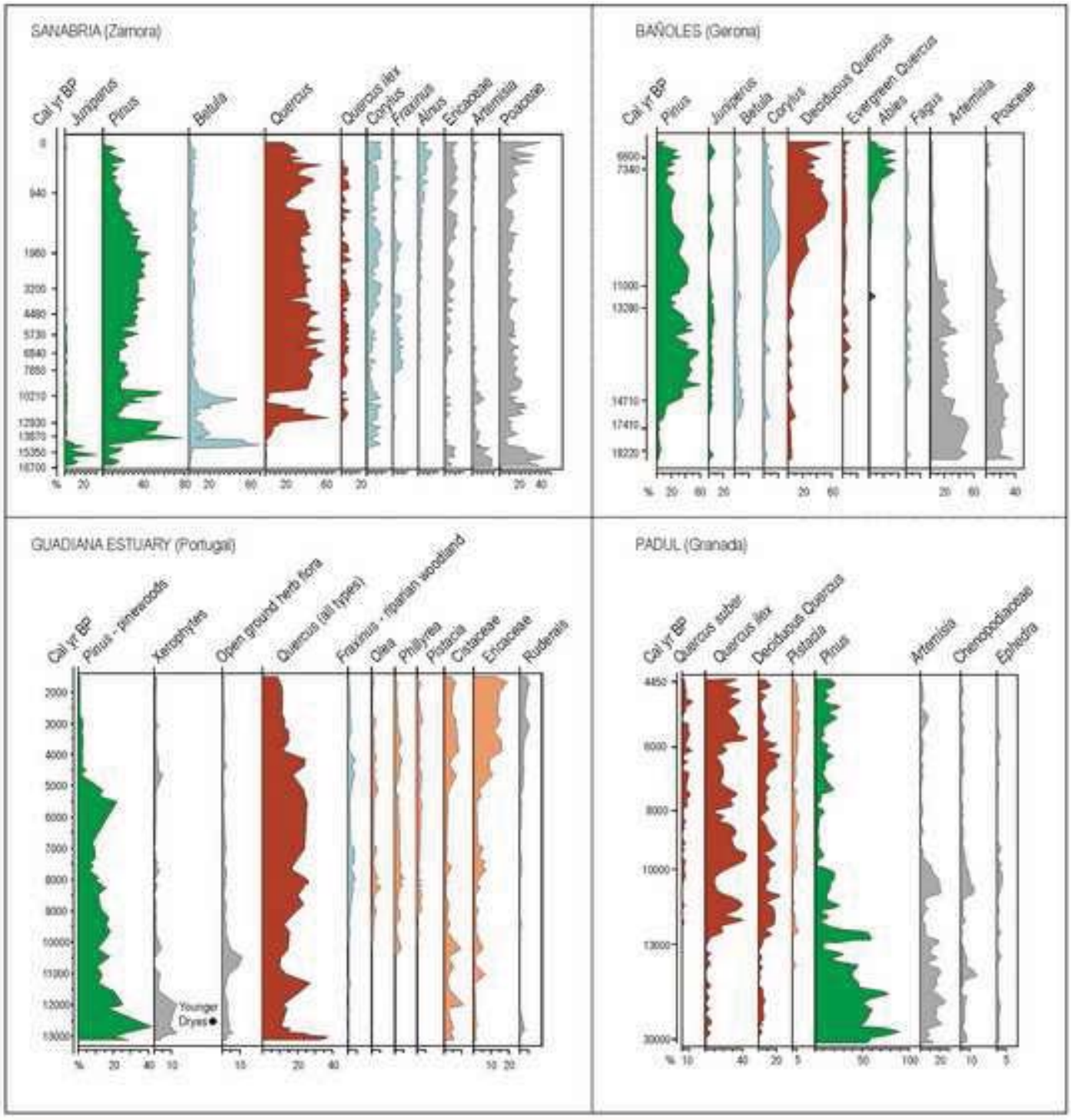

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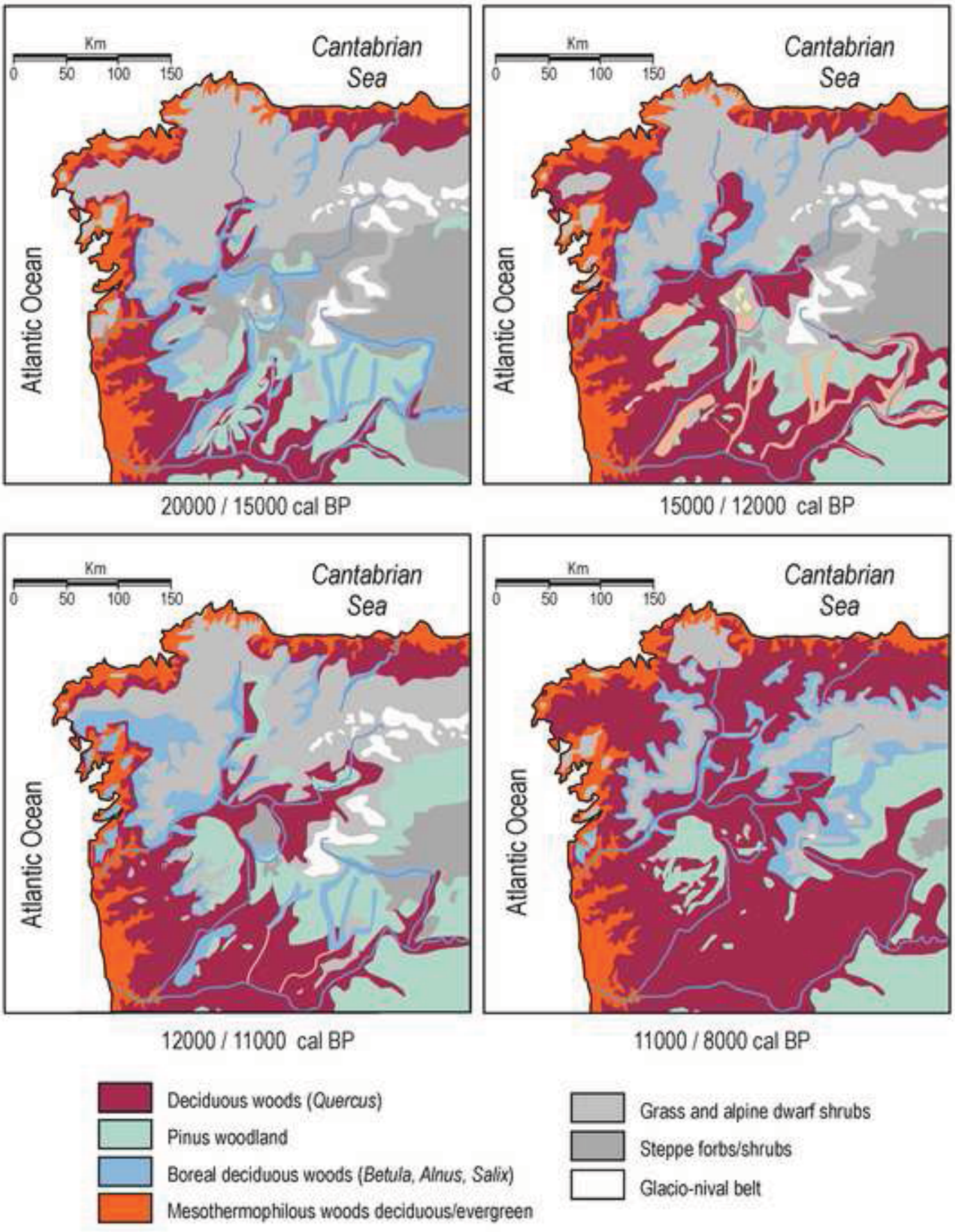

Figure 4

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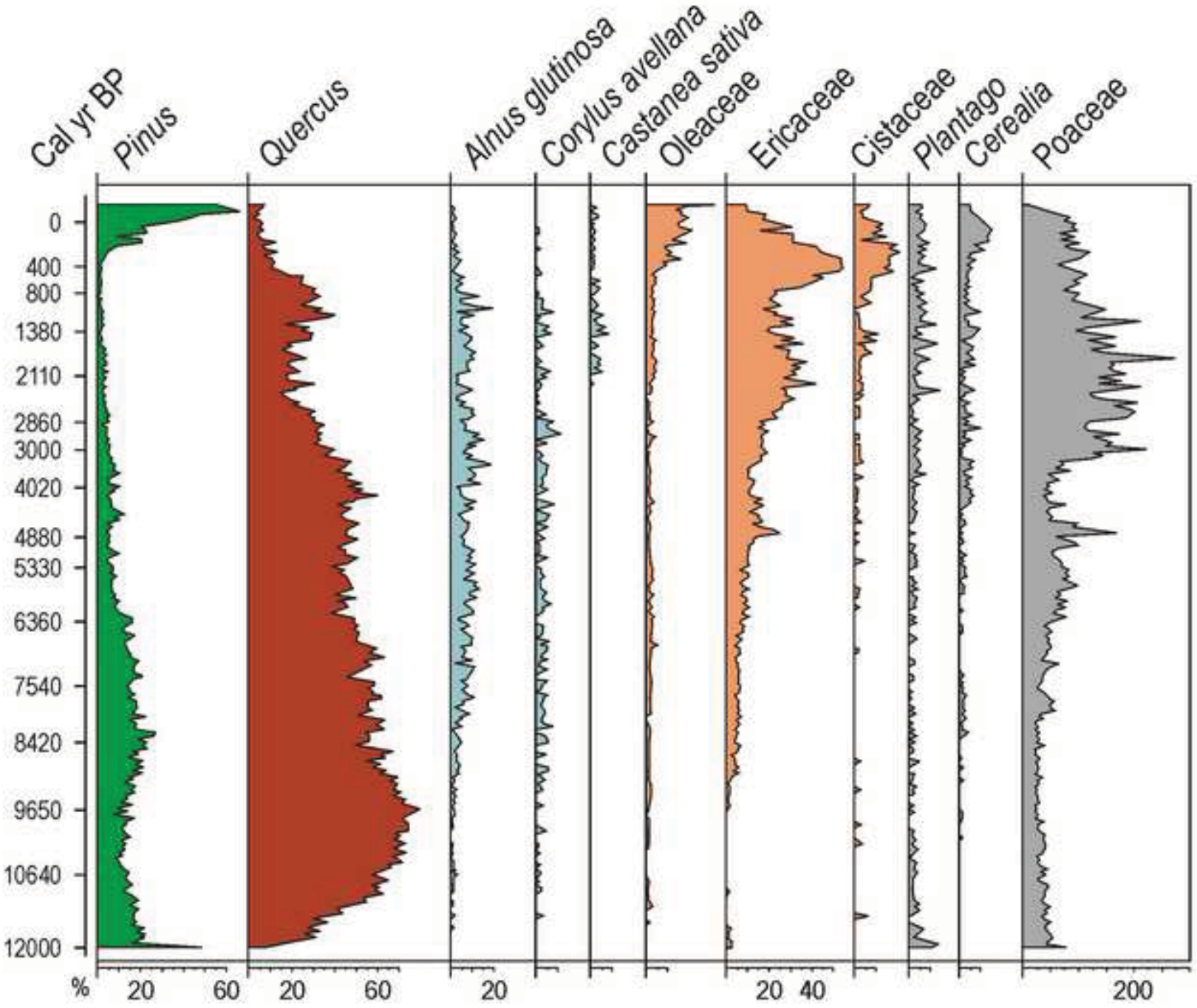

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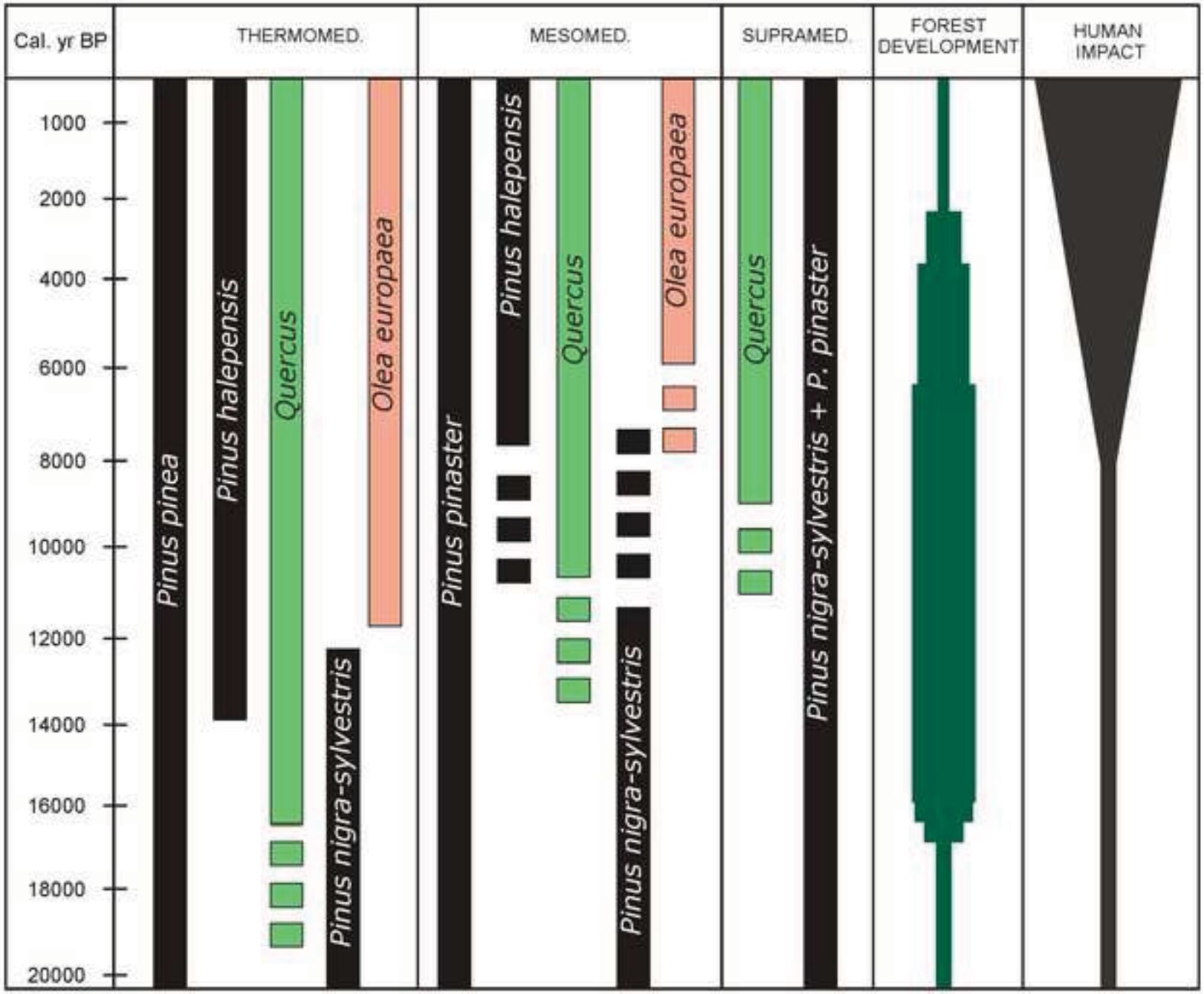

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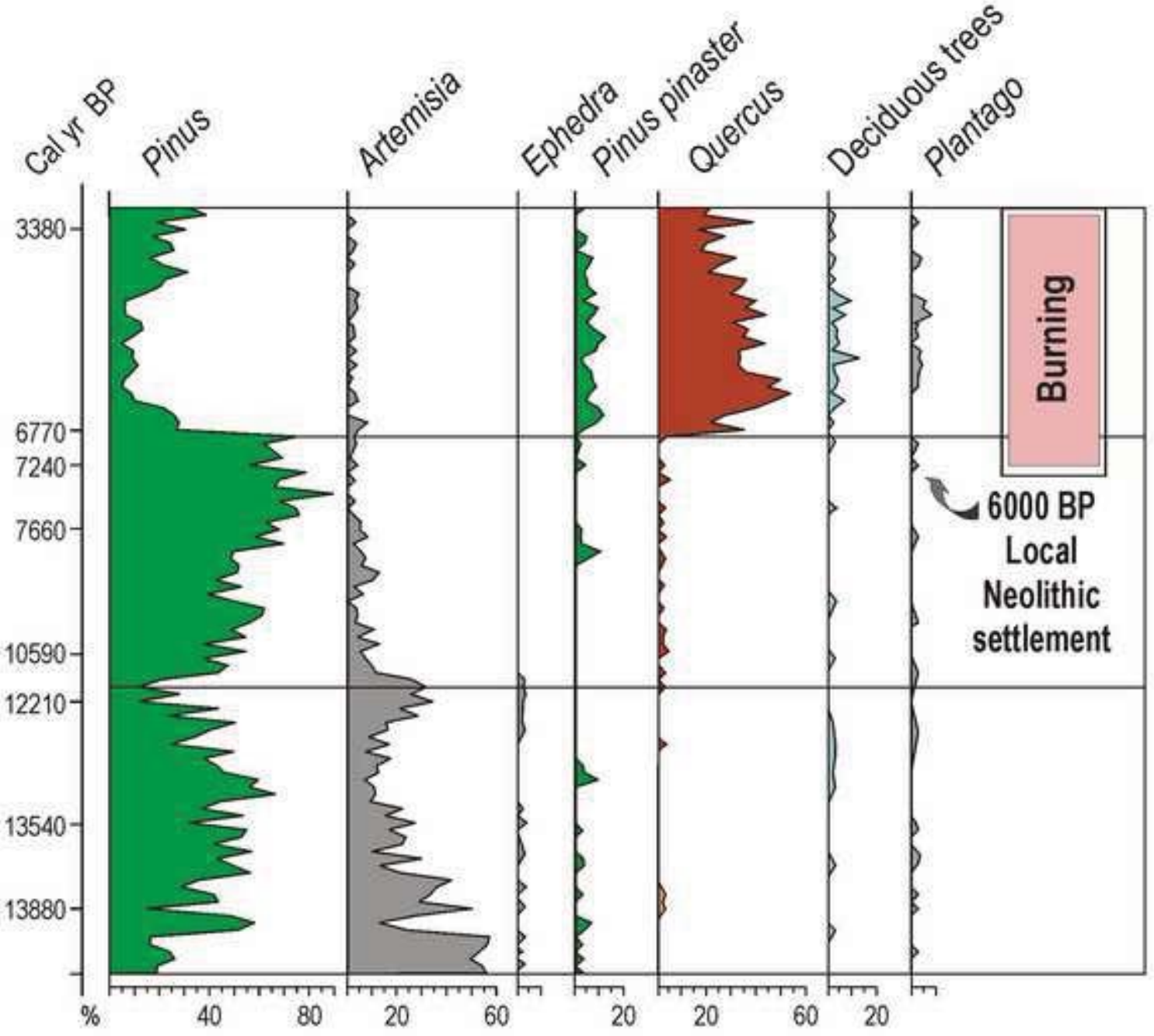

Figure 7

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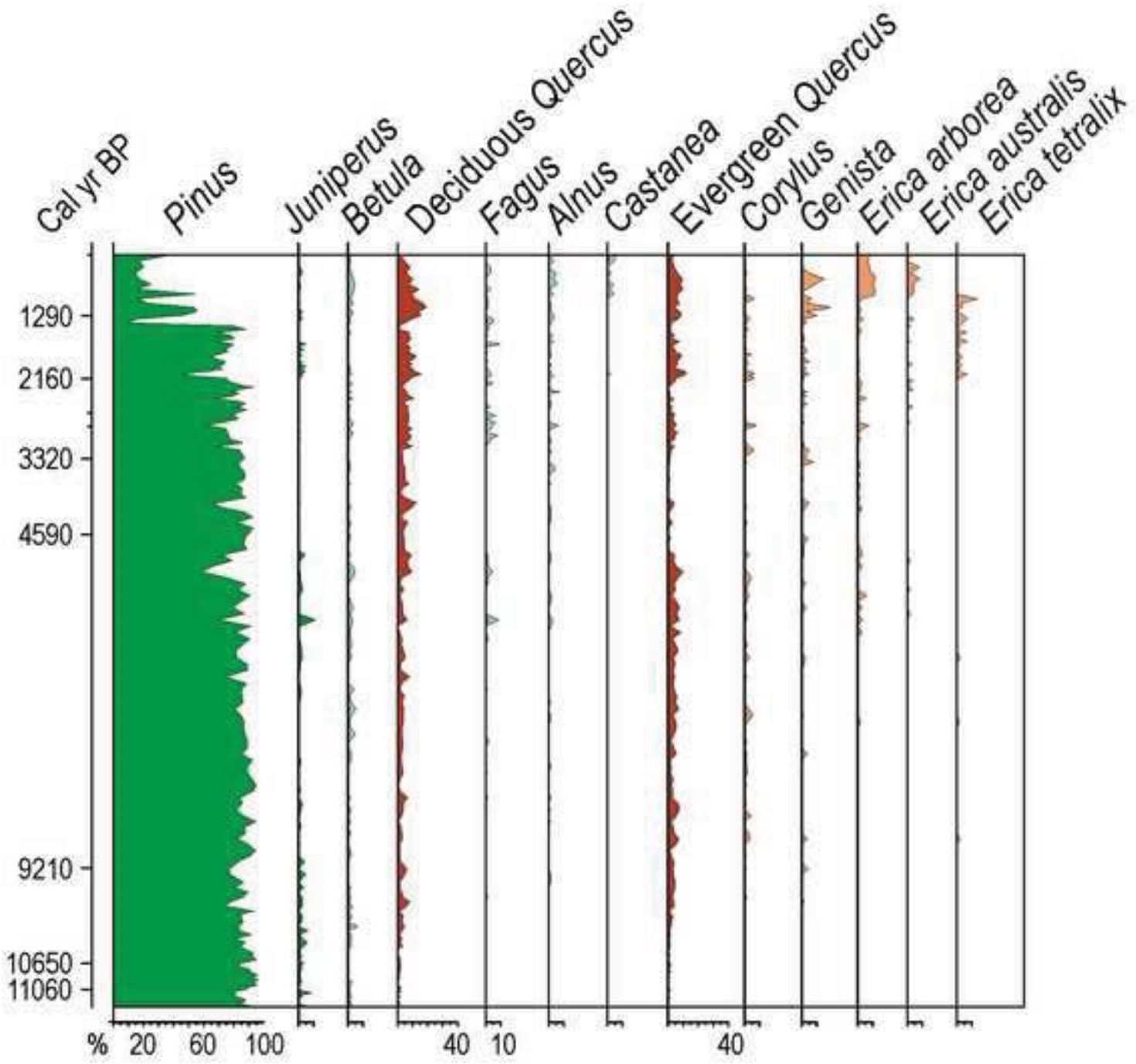

Figure 8

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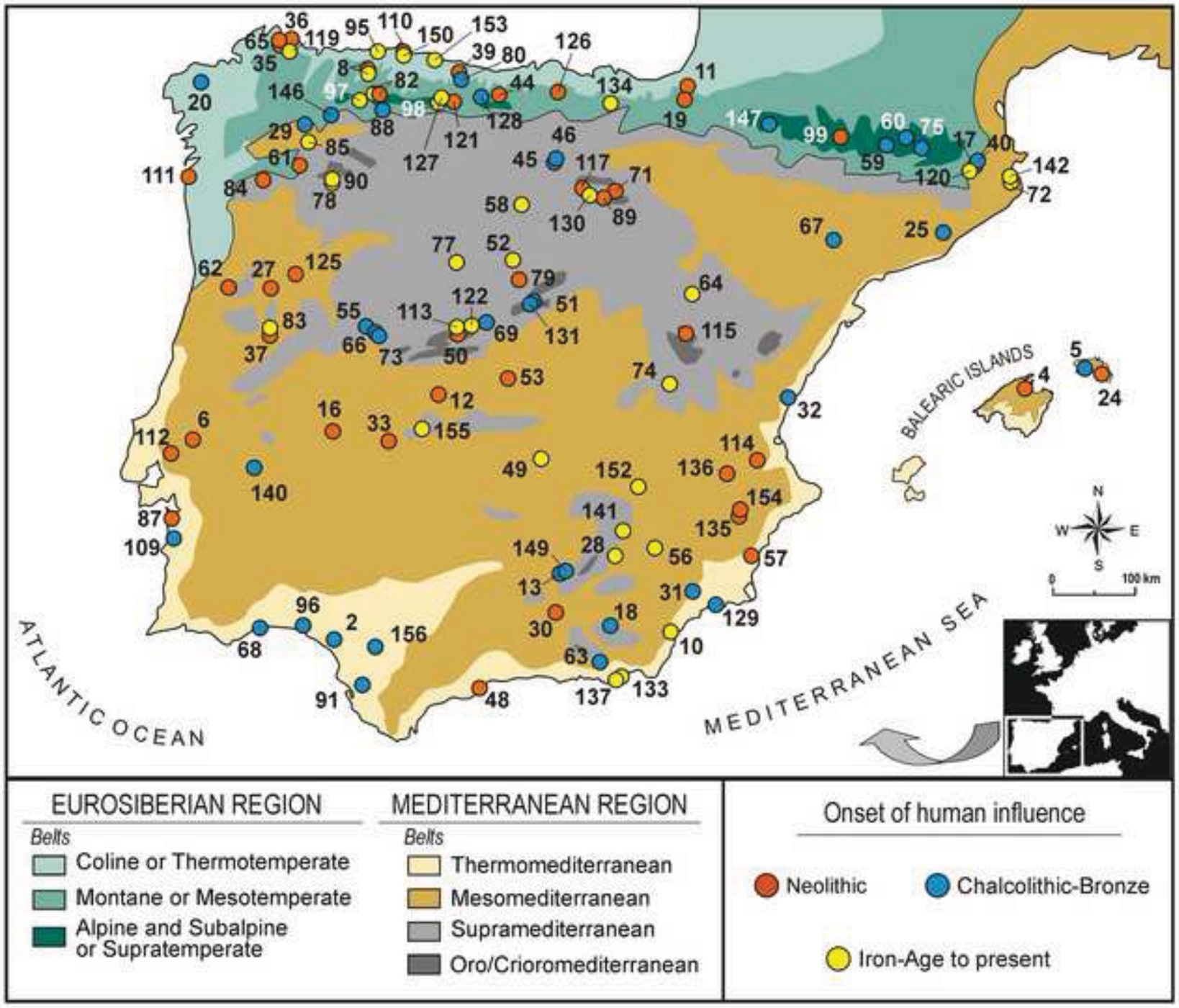

Figure 9

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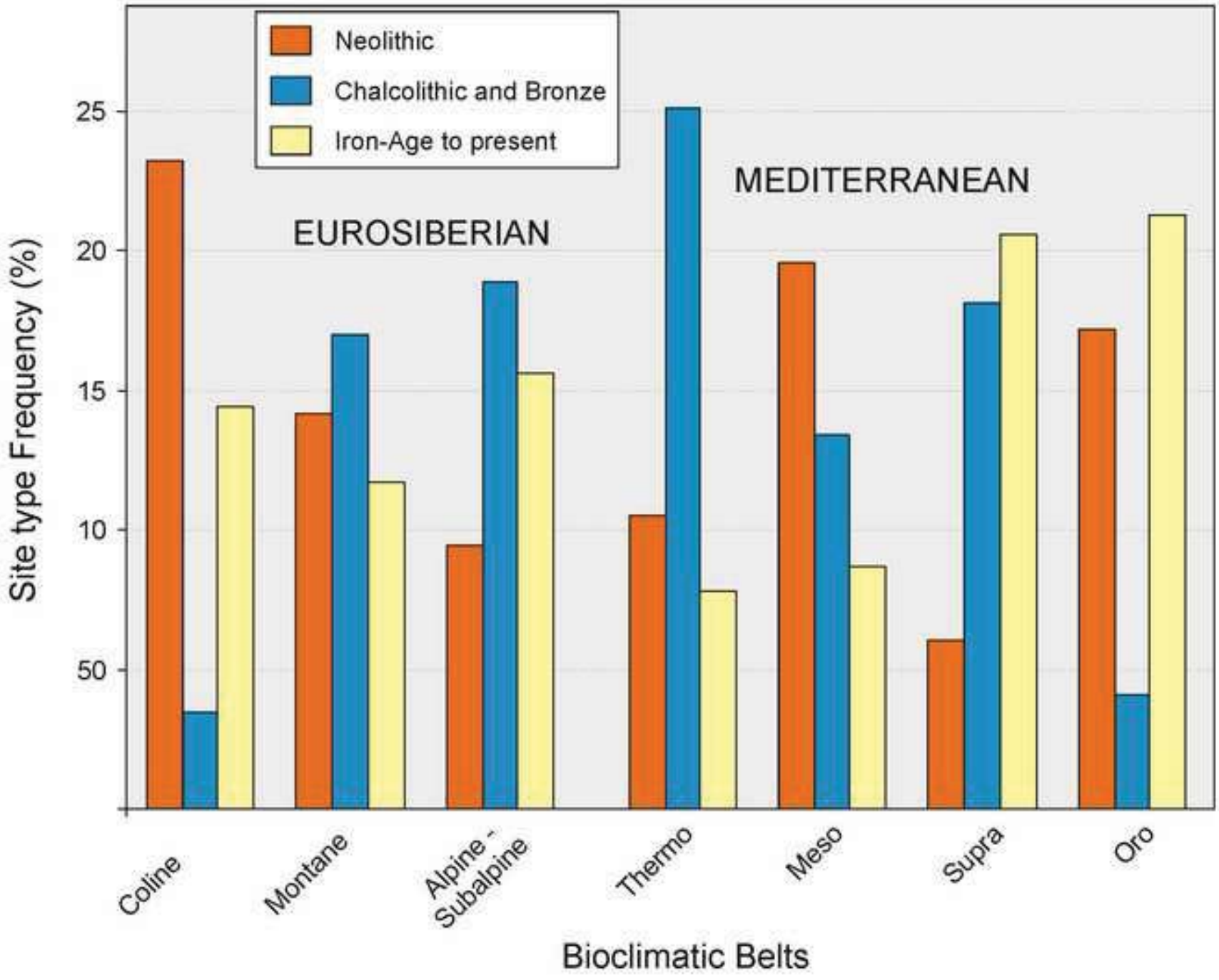

Figure 10

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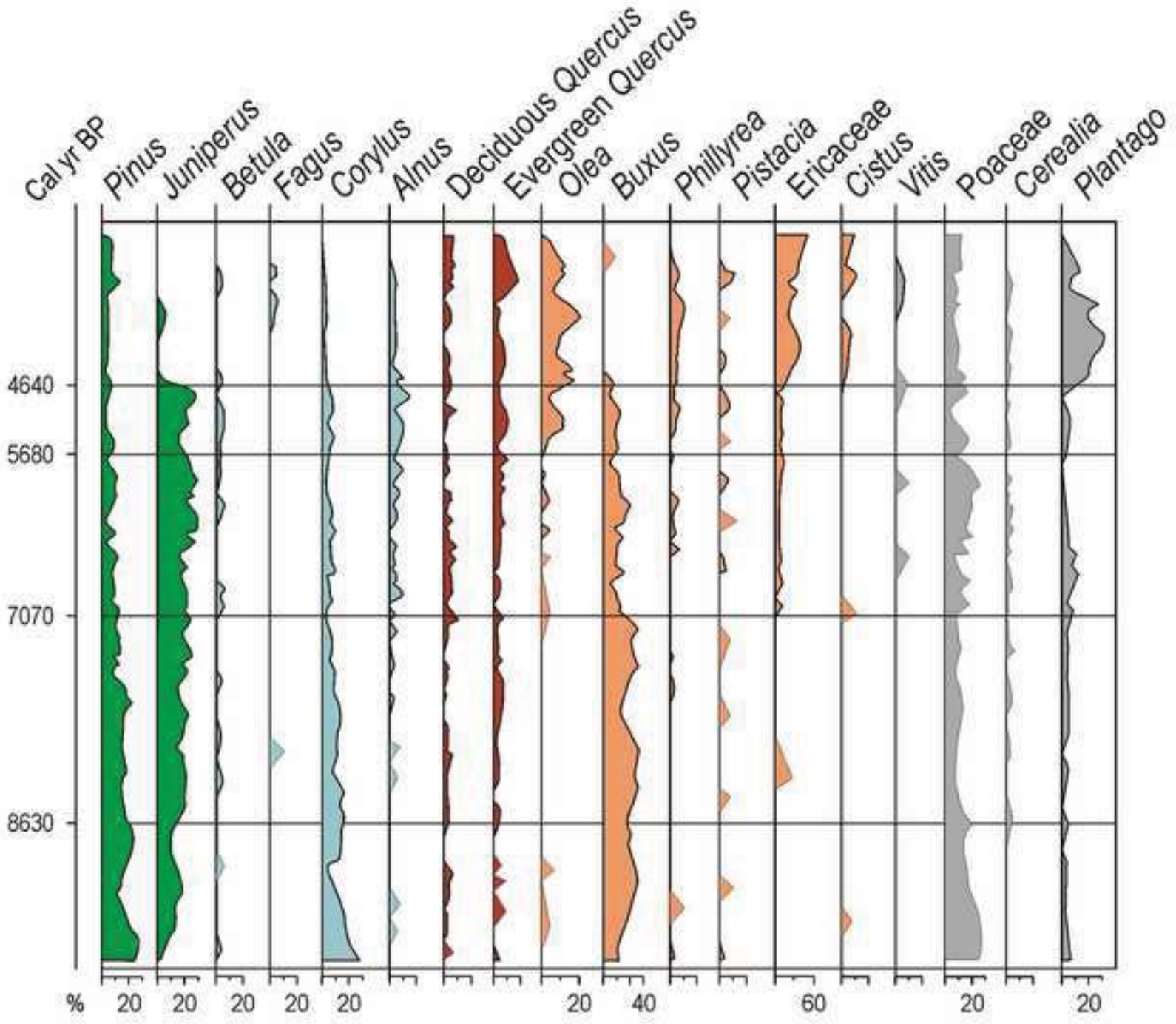

Figure 11

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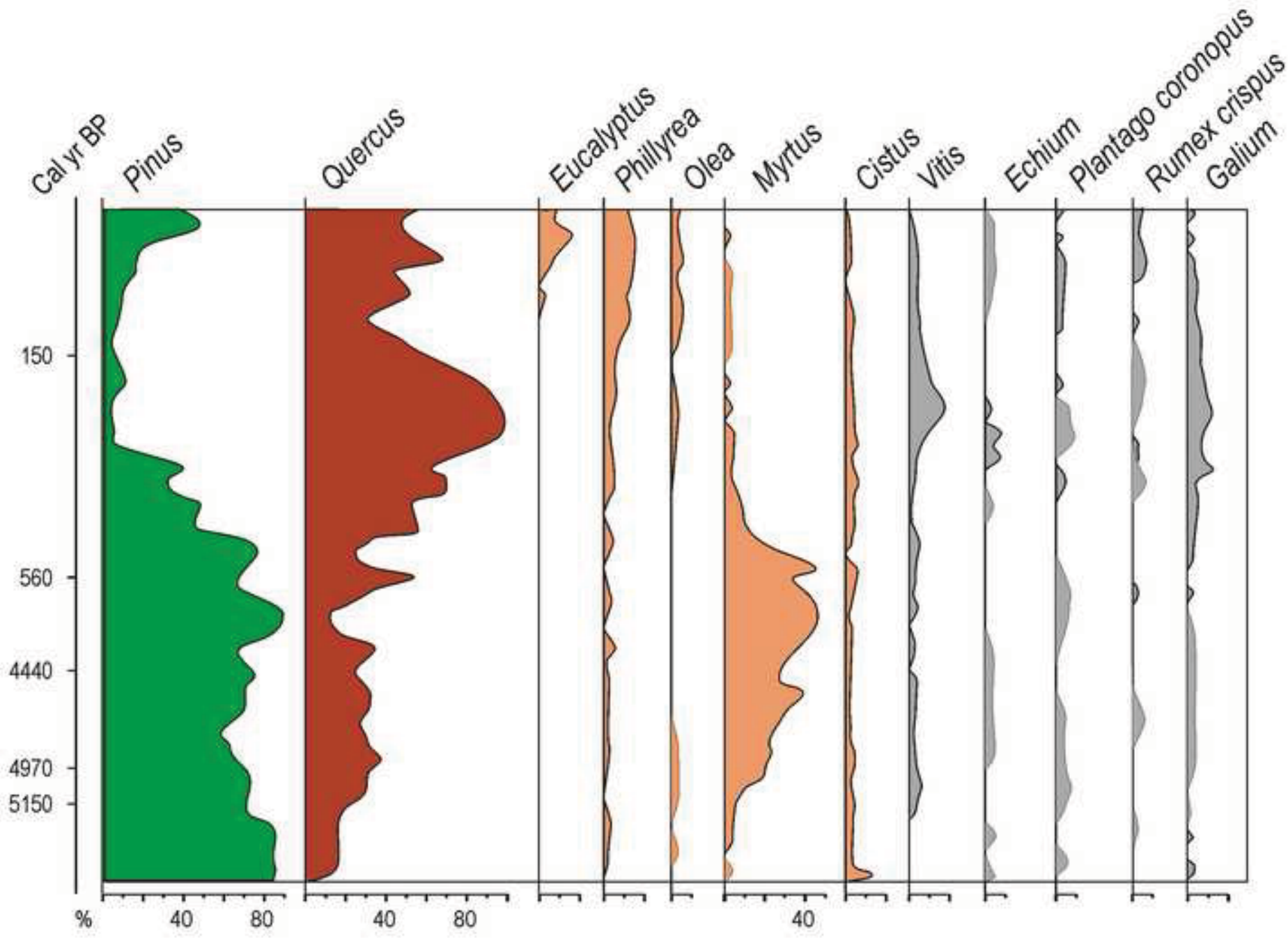

Figure 12
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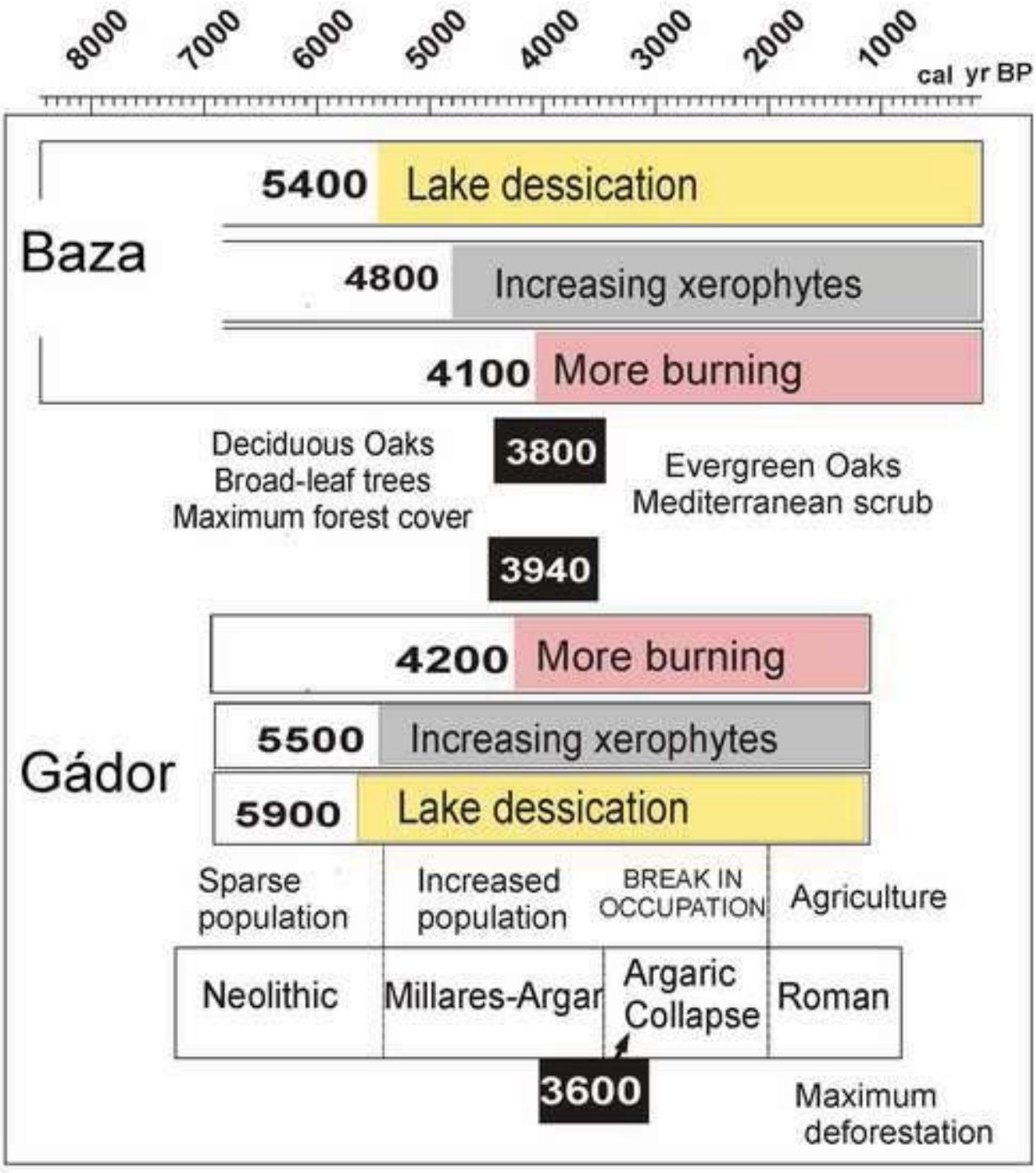

Figure 13
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